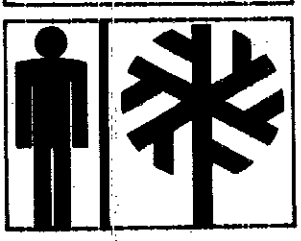
draft

environmental statement

NATURAL RESOURCES MANAGEMENT PLAN

HAWAII VOLCANOES



NATIONAL PARK ● HAWAII

DEPARTMENT OF THE INTERIOR

DRAFT
ENVIRONMENTAL STATEMENT

DES 73-67

NATURAL RESOURCES MANAGEMENT PLAN

Hawaii Volcanoes National Park

Hawaii

Prepared by

HAWAII VOLCANOES NATIONAL PARK
NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

Regional Director, Western Region

OCT 26 1973

NATURAL RESOURCES MANAGEMENT PLAN
HAWAII VOLCANOES NATIONAL PARK

DRAFT ENVIRONMENTAL STATEMENT

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SUMMARY

(X) Draft ( ) Final Environmental Statement

Department of the Interior, National Park Service, Western Region

1. Type of Action: (X) Administrative ( ) Legislative

2. Brief Description of Action: This is a composite plan of biologic research, propagating rare and endangered plant species, reintroducing rare plants into former range, protecting rare endemic biota from depredation by feral goats and pigs, and re-establishing and nurturing remnants of endemic Hawaiian ecosystems. It is aimed at fulfilling applicable Congressional mandates for a natural category park.

3. Summary of Environmental Impact and Adverse Environmental Effects: a. The beneficial impact of this action is that it will again allow the park's native Hawaiian ecosystems to operate largely without the influence and destruction of modern man, his activities, and the exotic species introduced by him. b. Adverse effects of the plan are 46 miles of interior fences which will result.

4. Alternatives Considered: a. Change our Service policies and our objective in managing the park's biologic resources from ". . .conserving. . .endemic Hawaiian ecosystems. . .for visitor use and enjoyment" to "conserving. . .all living things. . .for visitor use and enjoyment." b. Related to specific techniques of goat control: (1) have all reduction done by local citizens, (2) have reduction done by private local contractors for their profit, (3) eliminate goats by NPS personnel by any means possible, (4) do not construct fences, and/or (5) do no control work. c. Related to reintroducing rare plants we considered doing nothing; i.e., do not raise rare plants and reintroduce them.

5. Comments Have Been Requested From the Following:

Advisory Council on Historic Preservation
Department of Agriculture
  Soil Conservation Service
Department of Defense
  U.S. Army
Department of the Interior
  Bureau of Indian Affairs
  Bureau of Mines
  Bureau of Land Management
  Bureau of Outdoor Recreation
  Bureau of Reclamation
  Bureau of Sport Fisheries and Wildlife
  Geological Survey
Department of Transportation
Environmental Protection Agency
State of Hawaii Clearinghouse
State Historic Preservation Officer
County of Hawaii
Wilderness Society
Sierra Club
The Nature Conservancy
University of Hawaii
Bishop Museum
Society of American Foresters
Congress of the Hawaiian People
The Hawaiians
Audubon Society
Life of the Land

6. Date Statement Made Available to CEQ and the Public: OCT 26 1973

DESCRIPTION OF THE PROPOSAL

The natural history resources of Hawaii Volcanoes National Park are an extensive and exceptional remnant of Hawaii's native biota. The island's isolated biologic life is duplicated nowhere else on earth. Though these ecosystems are well on their way to massive destruction with continuing extinctions of many Hawaiian species, there are opportunities at Hawaii Volcanoes National Park to preserve and restore a sample of natural Hawaiian biota including representative major vegetation communities from the 13,680-foot summit of Mauna Loa to the sea.

To that end, this resource proposal is a composite plan of biologic research, propagating rare and endangered plant and animal species, reintroducing rare species into former range, protecting rare endemic biota from depredation by species introduced by modern man, and providing avenues for public knowledge of these unique Hawaiian ecosystems.

The plan is also aimed at fulfilling applicable Congressional mandates for a Natural Category national park. Authority for the various aspects of the plan is found in the enabling legislation for Hawaii National Park, "National Park Service Administrative Policies" and Title 36, "Code of Federal Regulations."

The plan was also guided by and concurs with the concepts of resources management presented in the Hawaii Volcanoes National Park Master Plan. Pertinent to the park's natural history resources, the Master Plan states the following park objectives:

> Conduct and encourage natural history research focused upon (1) further definition and insight into the park's native island ecosystems, (2) developing life history and ecologic understanding of species facing extinction, and (3) developing management strategies for preserving endemic island ecosystems.
>
> Preserve the evolving natural scene by protecting outstanding geologic features, such as the calderas and rift zones, steam and sulphur banks, the profile of Mauna Loa, and the associated native ecosystems.
>
> Re-establish park's endemic species into former range, concentrating efforts of those species which are in danger of extinction, and those that are key components of major native ecosystems.
>
> Protect the park's remnant Hawaiian ecosystems--including endangered species--from further depredation and competition by those exotic animals and plants introduced by modern man.
>
> Seek legislation to identify the Olaa Tract as a detached portion of Hawaii Volcanoes National Park. Until that is accomplished, manage, preserve, and interpret the tract with objectives suitable for a natural area of the National Park System.

Develop an interpretive program predicated on the three themes of particular significance in Hawaii Volcanoes National Park. The primary story is the active volcanism from which the Island of Hawaii is evolving, as illustrated by the Mauna Loa and Kilauea Volcanoes. The story of the native ecosystems and the threats to their survival resulting from introduced plants and animals is second in importance to the geologic story. Another secondary theme will be prehistoric and historic events.

The natural resource actions now underway, and those proposed, are summarized under broad headings as follows:

I. Re-establish endemic Hawaiian species into former range.

A. Plants that are key components of major native ecosystems. Mamani, naio, ohia, and koa are raised from seed in greenhouses at Kilauea Headquarters and the Ainahou Ranch for use in plantings along such developed and spoil areas as road cuts, restored building sites, and damaged areas. Some 2,500 seedlings and transplants of these species are planted annually. Additionally, over a 5-year period about 50,000 seedlings of mamani are being planted on the recently acquired Ainahou Ranch and within goat-free exclosure units. Approximately 30,000 acres of potential lowland mamani forest are being planted on defined areas representing 25 percent of the potential lowland mamani shrub forest areas. Unplanted zones within the suitable potential sites are deliberate--to allow research opportunity to assess vegetation responses on goat-free areas without the variable of planting programs.

Pili grass seed is broadcast at specific lowland sites to restore damage by construction and fire suppression lines in an attempt to thwart invasions by exotic grasses. These have been ongoing projects for many years but have been expanded into the Ainahou Ranch and the newly constructed goat exclosures.

Table 1. Planted species that are key components of major native ecosystems.

Plant		Seed Sources
koa	Acacia koa	Kipuka Ki
mamani	Sophora chrysophylla	Park areas near planting site
ohia	Metrosideros collina	Park areas near planting site
naio	Myoporum sandwicensis	Park areas near planting site
pili grass	Heteropogon contortus	Kalapana

B. Rare plants known to occur (or to have occurred) within the park. The following plants are raised in greenhouses at Kilauea Headquarters and the Ainahou Ranch (see Table 2). Approximately 10,000 seedlings will be raised each year and planted on defined areas within exclosure units and other goat-free areas.

As former habitat of these plants is relieved from destruction by goats, excellent opportunity exists for native Hawaiian plant communities to re-establish themselves. However, in the case of the species listed, we doubt that a natural seed source still is present. Therefore, we propose to plant these species in park areas that by soil and climate conditions appear to fall within the species' former range. This is an ongoing program with a notable lack of success thus far; as fast as these species are transplanted, goats gobble them up. This program is totally dependent upon building fenced goat exclosures along the pali areas.

The number of plants managed in this manner will be reduced as species are successfully re-established and their survival appears secure. It will be expanded to include additional plants that continuing research identifies as rare and endangered, and for which suitable park seed sources are available.

C. Rare and endangered plants suspected of once occurring in the park. Five species of rare and endangered plants in jeopardy in their present wild state, are suspected of once occurring within the park. These species are being raised from seed or cuttings for planting within the park. About 200 plants per year of each species are planted on mapped areas totalling 30 acres.

Table 2. Rare plants known to occur (or have occurred) in the park that are being raised and planted.

Plant		Seed Source	Approx. Acreage Subject to Planting
tree fern[1/]	*Cibotium hawaiiense (Fig. 34)	None now	10
awikiwiki	*Canavalia kauensis (Fig. 13)	Kukalauula Pali	100
ohai	*Sesbania tomentosa (Fig. 14)	Apua Point	1,000
hau-kuahiwi	*Hibiscadelphus giffardianus (Fig. 15)	Kipuka Ki	100
aiea[1/]	*Nothocestrum breviflorum (Fig. 17)	Naulu Forest and Napau Trail	100
aiea	*Nothocestrum longifolium (Fig. 18)	Kipuka Puaulu, Kipuka Ki	100
ahakea	*Bobea timonioides (Fig. 19)	Naulu Forest	1,000
naupaka	*Scaevola kilaueae (Fig. 20)	Hilina Pali Road	10
[1/]	**Stenogyne angustifolia var. angustifolia (Fig. 21)	None now	<10
hame	Antidesma pulvinatum (Fig. 22)	Naulu Forest	1,000
ohe makai	Reynoldsia hillebrandii (Fig. 23)	Poliokeawe Pali, Kamoamoa Pali	1,000
halapepe	Pleomele aurea (Fig. 24)	Poliokeawe Pali, Naulu Forest	1,000
kauila	*Alphitonia ponderosa (Fig. 25)	Kipuka Nene, Poliokeawe Pali, Naulu Forest	10,000
ae	*Zanthoxylum dipetalum var. geminicarpum (Fig. 26)	Kipuka Puaulu	100
ae[1/]	*Zanthoxylum hawaiiense var. citriodora	None now	100
kului	Nototrichium sandwicense var. macrophyllum (Fig. 27)	Hilina Pali	1,000

* Candidates for listing as endangered species.
** May already be extinct.
1/ Not being raised now.

Table 2. Rare plants known to occur (or have occurred) in the park that are being raised and planted. (continued)

Plant		Seed Source	Approx. Acreage Subject to Planting
ohe mauka	Tetraplasandra hawaiiensis var. hawaiiensis (Fig. 28)	Naulu Forest	5,000
papala	Charpentiera obovata (Fig. 29)	Kipuka Puaulu	100
holei	*Ochrosia sandwicensis (Fig. 30)	Kipuka Puaulu	100
loulu palm	*Pritchardia beccariana	Olaa Tract	10
loulu palm	*Pritchardia affinis	Hilo[2/], Kaimu Beach[2/]	100
sandlewood	Santalum ellipticum	Poliokeawe Pali, Pauahi Crater	1,000
hoawa	*Pittosporum hosmeri (Fig. 31)	Kipuka Puaulu	1,000
wiliwili	Erythrina sandwicensis	Wahaula, Kamoamoa, Makahanu	1,000
hao	*Rauvolfia remotiflora (Fig. 35)	Poliokeawe Pali	1,000
silversword	***Argyroxiphium sandwicense (Fig. 32)	Mauna Loa Trail 8,200', Red Hill	1,000
oloa[1/]	*Neraudia ovata (Fig. 33)	Halfway House 3,000' (?)	<10
ohelo[1/]	*Vaccinium pahalae (Fig. 36)	None now	10
kokoolau	*Bidens skottsbergii	Hilina Pali Road	1,000
pelea	*Pelea puauluensis	Kipuka Puaulu	10
pelea	*Pelea zahlbruckneri	Kipuka Puaulu	10
manena	*Pelea hawaiiensis var. gaudichaudii	Kipuka Puaulu	10
maua	Xylosma hawaiiensis var. hillebrandii	Naulu Forest	1,000
kou	Cordia subcordata	Halape	100

* Candidates for listing as endangered species.
*** Keep existing stands intact with supplemental plantings in same area as seed source until further studies clarify taxonomy of park plants.
1/ Not being raised now.
2/ Seed source is not within Hawaii Volcanoes National Park; all others are.

Table 3. Planting program involving rare plants suspected of once occurring within the park.

	Plant	Seed Source We Are Using	Approx. Acreage Subject to Planting
uhiuhi	*Mezoneuron kauaiense (Fig. 37)	Puuwaawaa, Kona[2/]	<10
kokio	*Kokia drynarioides (Fig. 38)	Kipukas Nene and Puaulu[3/]	<10
hau-kuahiwi	*Hibiscadelphus hualalaiensis (Fig. 16)	Kipuka Puaulu[3/] and Puuwaawaa[2/]	<10
mao	*Gouania hawaiiensis	None Now	<10
kauila	*Colubrina oppositifolia	Puuwaawaa, Kona	<10

D. BIRDS. Several birds on the Department of the Interior's endangered list occur--or did occur--within the park. These are Hawaiian dark-rumped petrel, Hawaiian hawk, nene, Hawaiian crow, Hawaii akepa, akiapolaau, and ou.[4/] As endemic Hawaiian ecosystems recover--by the proposals to control exotics and restore endemic plants--there may be opportunity to re-establish rare endemic birds into former range. We propose the following actions related to these endangered bird species:

*Nene formerly bred throughout the park below alpine areas (Fig. 39). We propose to construct six 1-acre nene breeding pens on the pali areas in the vicinity of the Ainahou. Each pen (of woven wire 10 feet high) will be stocked with a pair of birds from Pohakuloa. At present 2,400-acre and 6,200-acre goat exclosures are under construction. Native plants are being reintroduced in both exclosures. With this habitat restoration, there is a possibility that offspring from the two breeding pens will survive and re-inhabit this former nene range. One pen is completed and stocked with a pair of nene; another pen is under construction.

*Dark-rumped petrel (Fig.40) formerly bred in the Kau Desert and probably near Red Hill on Mauna Loa. We propose to study

* asterick indicates endangered species
2/ Seed source is not within Hawaii Volcanoes National Park; all others are.
3/ These plants probably were originally from Puuwaawaa.
4/ Additionally, the Hawaii creeper is nearly as rare and as restricted range as both the akiapolaau or Hawaii akepa. We expect it will be cited as "endangered" on the next revision of the Department's official endangered list. The Newell's Manx shearwater is "threatened."

the feasibility and strategy for re-establishing breeding colonies in these vicinities. At present lava flows could easily obliterate the only dark-rumped petrel breeding areas on the Island of Hawaii.

The *Hawaiian hawk and the creeper will benefit from habitat restoration. Populations of these species are adequate to expand into suitable habitats; protection and restoration of environments for these species are crucial.

Populations of *ou, *akepa, and *akiapolaau are so low--and declining--that we propose priority efforts at habitat protection and restoration in areas near remnant populations of these species (Figs. 41 to 43). Studies aimed at life history knowledge and developing strategies for reintroducing birds into former ranges in the park as habitats are restored are programmed.

The remnant population of *Hawaiian crow is too far removed from the park to naturally repopulate this area even if we are able to restore park habitats. After habitats are well along to recovery we will seek assistance from endangered species biologists of Bureau of Sport Fisheries and Wildlife and the Hawaii State Division of Fish and Game in developing remaining alternatives to restore crow populations to this former range, if the species is still surviving at that time.

II. Protect remnant Hawaiian ecosystems from exotics introduced by man.

A. GOATS: We propose to reduce and control the numbers and distribution of goats to a degree that endangered Hawaiian plants can survive and become re-established on their former range within the park. Our actions to effect this are:

1. Reconstruct and maintain 70 miles of existing boundary and drift fences (Fig. 1) to prevent movement of goats into the park from adjacent ranch lands. We have begun this reconstruction and plan to complete it by 1974. This fence directly affects all other components of the proposed plan; other actions are fruitless if we don't prevent continual new infiltration of feral goats from outside the park.

   We propose to replace the existing fence with a 4-foot high hog-wire fence strung on T-type steel posts placed 15 feet apart.

   Fencing specifications are: woven wire fence, CF&I 1047-6-12½ and post T-type, painted hot rolled carbon or rail steel 1/8-inch thick. Between posts on uneven terrain anchor wires of #8 gauge wire to be installed. Fence must have less than a

* asterisks indicate endangered species

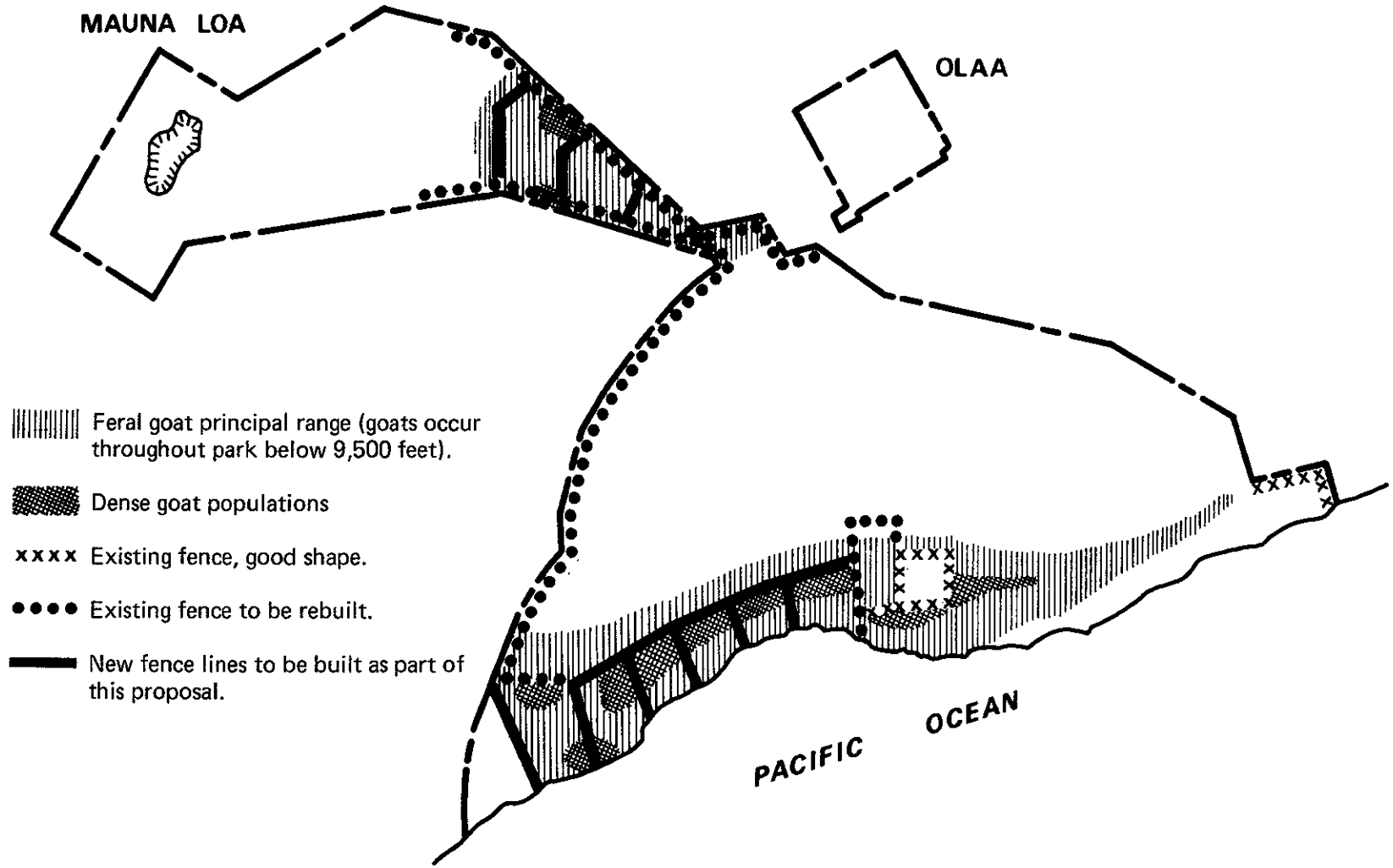


Fig. 1. Distribution of goats in the park and location of fences to be used in goat control proposals.

FIG. 2 Bird Park fence. This is the character of an interior drift and exclosure fence proposed for construction in this plan.

4-inch gap with the ground. Fence right-of-way is not to be levelled or bulldozed. Fence is to follow the lay of the land so that the land surface remains undisturbed. Old fence is to be removed from the site.

2. Construct and maintain 46 miles of drift and exclosure fence (Fig. 1) to exclude goats from critical endemic plant areas and to assist in goat control measures. This work is ongoing and expected to be completed in 1976. These fences directly affect the success in saving remnant plant species from extinction and our efforts to reintroduce these species into their former range. Too, they will allow us to drive goats shorter distances for capture, which is more humane for the animals involved. The fencing is similar to 1 above except that the vertical stays are 12 inches apart (CF&I 1047-12-12½).

3. In areas where effective, remove goats from the park by means that allow local citizen participation in the reduction and disposal of excess goats. This is ongoing and would continue as long as the people show interest by their participation. We deputize citizens as park rangers for purposes of goat control. They kill or capture goats in areas and at times designated by the Park Superintendent, and act under control and direction of Park Rangers. Figures 3 and 4 show 1970-71 numbers of people participating and goats removed by areas. The data suggests that this program is popular and effective where goat populations are very high--but that public interest wanes where goat numbers are held at lower levels. We speculate that goat populations held to a low enough level for endemic Hawaiian plants to flourish will be too small to interest citizen goat hunters.

4. In areas where feasible, remove goats from the park by drives and roundups conducted by park personnel with trained goat dogs and using fences shown in Figure 1. Live goats so captured will be sold to public bidders.

5. Where other means are insufficient or impossible we will assign park rangers, using trained goat dogs to hunt and kill excess goats.

Goat removal efforts (Fig. 5) by various methods have been an ongoing action for many years. However, lacking adequate internal fencing and adequate boundary fence maintenance--its been impossible to maintain low goat populations. Goats have been the dominant factor in the continual destruction of native Hawaiian plants and ecosystems in the park (Fig. 12a). Still, within the park goat reductions have been persistent; we still

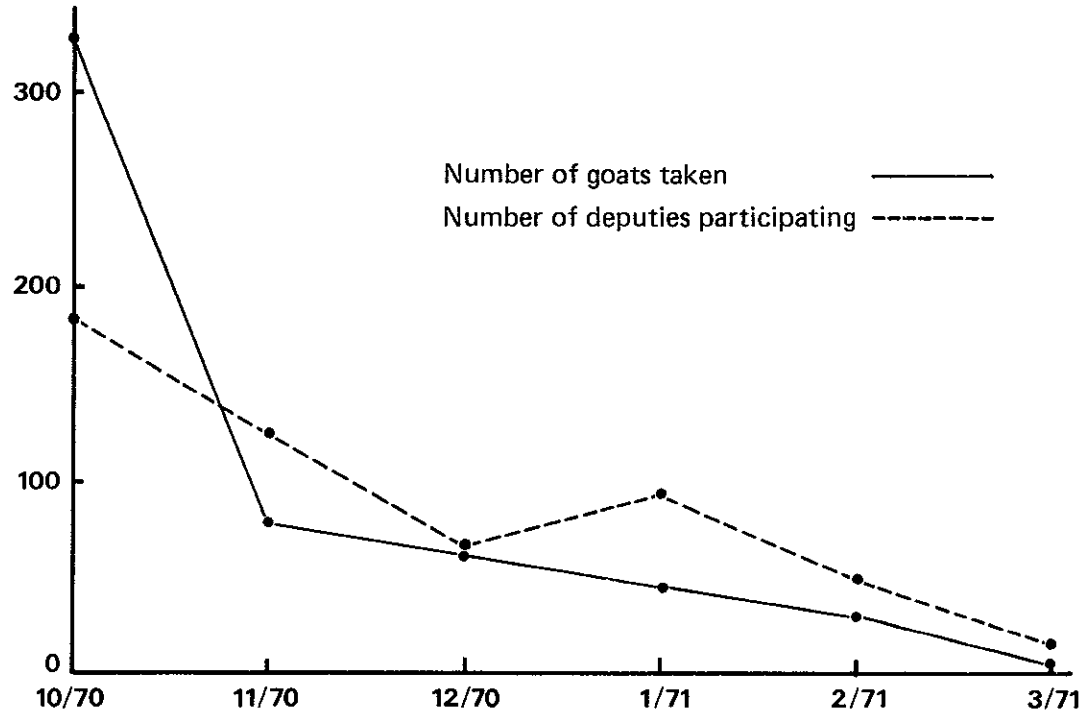


Fig. 3. Number of deputy rangers participating and number of goats taken during a 6-month period of the Holei Pali Deputy Ranger Program.

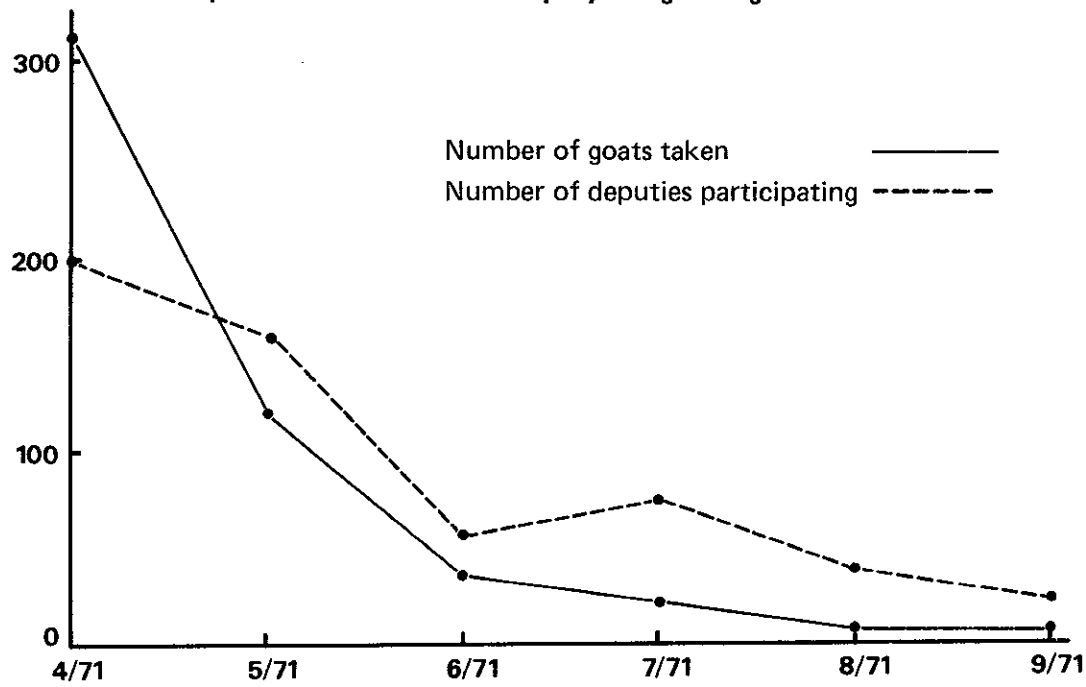


Fig. 4. Number of deputy rangers participating and number of goats taken during a 6-month period of the Deputy Ranger Program of the Kalapana Ranger Program.

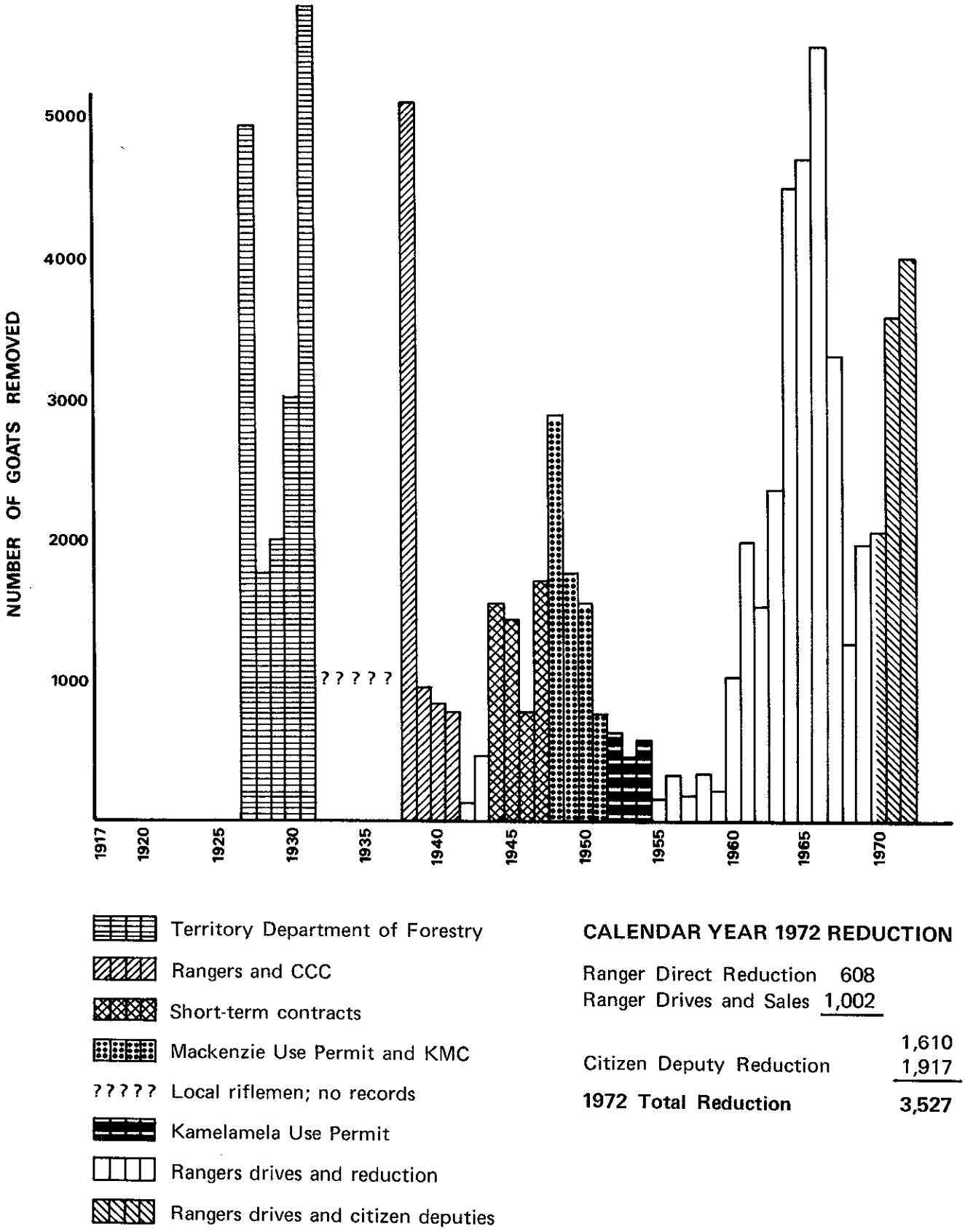


Fig. 5. Number of goats taken annually from Hawaii Volcanoes National Park.

have remnants of endemic Hawaiian plant systems. Elsewhere on Hawaii goat control is nil; there, endemic systems are largely destroyed (note distribution maps of endangered plant species, Figures 13 to 38).

Goat control proposals listed here are key to the entire resource plans. Without this portion of the proposal, it is useless to transplant plants into former ranges--goats eat the plants. Efforts to restore endangered bird populations (nene, the drepanids, crow) are futile without restoration of Hawaiian plant habitats.

B. PIGS: We propose to reduce and control the numbers and distribution of pigs as best we can to a degree that their effect upon native Hawaiian vegetation is minimal. Our actions to effect this are:

1. In areas where effective, remove pigs from the park by a means that would include local citizen participation in the reduction and disposal of excess pigs. We deputize citizens as Park Rangers for purposes of pig control. Using dogs, they kill or capture pigs in areas and at times designated by the Park Superintendent, and act under control and direction of Park Rangers. This program began in fall 1972 and continues as long as people show interest by their participation.

2. Assign Park Rangers to hunt and kill excess pigs. This is ongoing and will continue.

3. Research in pig population control measures. Using the Mauna Loa Strip goat exclosure (about 5,000 acres now being fenced) as a research area, carefully controlled studies in pig populations and various pig control measures will be undertaken. This study will begin in F.Y. 1975, continue for 5 years, and should form the basis for a rational effort in pig population control.

Though pig removal efforts have been continuing for many years, they have been inadequate to prevent pigs from rooting and destroying native Hawaiian vegetation. Pigs eat and spread seeds of exotic plants. Guava is largely spread by pigs. Control of exotic plants and protection of rare native plants is impossible without greater control of feral pigs.

C. RATS AND MONGOOSES: Rats and mongooses have done inestimable damage to endemic island biota. The destruction is continuing; yet, there is no present knowledge or technology available on which to base a park-wide plan of effective rat or mongoose population control. Therefore, no broad-scale control efforts are contemplated at this time.

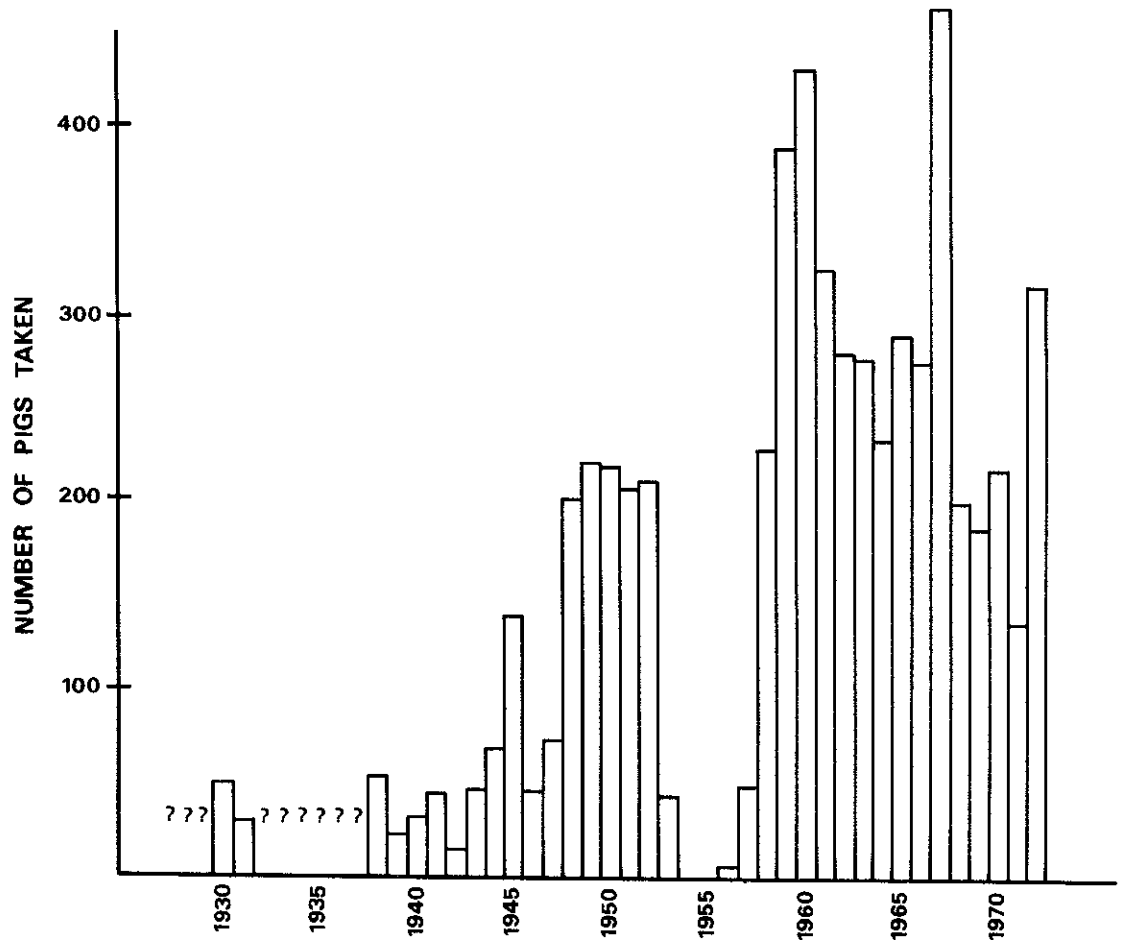


Fig. 6. Number of pigs taken by all methods in Hawaii Volcanoes National Park, 1927 to 1972.

The following management efforts are proposed:

1. Research aimed at better definition of the damage rats and mongooses are doing to native ecosystems (including rare species) and population control measures.

2. Specific control efforts at localized areas limited to nesting sites of dark-rumped petrel and Newell's Manx shearwater and in vicinity of the breeding pen experiments with nene. This control involves both live trapping and local, specific use of the poison Warfarin.

3. Control of back-country garbage disposal to reduce habitat for rats at such places as Red Hill Rest House (which is adjacent to a former nest site of dark-rumped petrel).

D. CONTROL OF EXOTIC PLANTS

More than 400 exotic plants are recorded within Hawaii Volcanoes National Park. At present, several of these (Table 4a) give cause for alarm because of their potential to take over widespread areas and cause major vegetation-type shifts away from native plant systems. This is particularly true in areas where goats and pigs eat the native plants. Two general techniques are used to control these plants:

1. Cut individual plants and apply approved herbicides such as Ammate-X, Karmex, or Dalpon to individual stems.

2. Cooperate with the State Department of Land and Natural Resources in finding natural biologic enemies for certain of the problem species. For example, State introduction of insects--lantana defoliater, Hypena strigata; leaf miner, Cremastobombycia lantanella; beetle, Octotoma scabripennis; and moth, Uroplata girardi--have been effective in impeding spread of the exotic shrub Lantana. Perhaps such biotic controls may someday be possible with blackberry and faya tree.

   We expect problems with exotic plants will be less when goat and pig populations are controlled.

Table 4. Exotic plants in Hawaii Volcanoes National Park that have high potential to take over Hawaiian ecosystems.

Name	Approximate Acreage Now Involved	Potential Acreage Involved	Control Technique Underway
Andropogon grass	25,000	60,000	No direct control
Guava	10,000	50,000	Cut and individually poisoned
Lantana	10,000	75,000	Biotic control; introduced insect enemy
Christmasberry	1,000	50,000	Cut and individually poisoned
Silky oak	500	50,000	Cut and individually poisoned
Ekoa	25	75,000	Cut and individually poisoned
Tibouchina	200	1,000	Cut and individually poisoned
Blackberry	scattered over 400	2,500	Spray or cut and individually poisoned
Faya tree	scattered over 25,000	75,000	Cut and individually poisoned
Wild olive	500	10,000	Cut and individually poisoned
Fountain grass	< 1	20,000+	Uprooted and poisoned when found
Cactus	<100	3,000	Individually cut and biological control

DESCRIPTION OF THE ENVIRONMENT[1/]

THE PARK

Geology[2/]

Hawaii Volcanoes National Park (Fig. 7) is the youngest part of the youngest of the United States. Its 220,000 acres extend from the Pacific shore to the dome-shaped tops of two active volcanoes, Mauna Loa (13,680 feet) and Kilauea (4,090 feet). During historic times, more years than not these mountains have been in eruption. New flows in the last few years cover 25 square miles of the park, are building a new mountain (Mauna Ulu), and are adding new lands to Hawaii where flows enter the sea. None of the park land surfaces are as old as Pliocene; some are as young as today.

Mauna Loa and Kilauea, the principal features of the park, are building layer after layer as the earth's magma extrudes from volcanic vents and solidifies as it flows toward the sea. Fundamental differences occur in the surface appearances of these volcanic deposits: (a) explosive eruptions cover areas with ash and rock fragments, (b) aa flows have rough clinkery surfaces and dense interiors, (c) pahoehoe flows have smooth surfaces and may have porous interiors and be dissected by cracks. Varying ages of rock surfaces occur. Kipukas--islands of older soils surrounded by younger lavas--often contain vegetation of older more mature successional stages.

The youthful land surfaces, particularly pahoehoe, are extremely porous. Water, even in areas of 100 inches annual rainfall, immediately percolates down to near sea level. Kilauea and Mauna Loa have no streams, lakes, or ponds--even intermittently.

1/ Based largely from:
Doty, M. S. and D. Mueller-Dombois. 1966. Atlas for Bioecology Studies in Hawaii Volcanoes National Park. Univ. of Hawaii. Hawaii Botanical Science Paper No. 2, 507 pp. mimeo.

2/ See also the excellent:
Macdonald, G. A. and A. T. Abbott, 1970. Volcanoes of the Sea; The Geology of Hawaii. Univ. of Hawaii Press. 441 pp.

Macdonald, G. A. and D. H. Hubbard. 1972. Volcanoes of the National Parks of Hawaii. Hawaii Natural History Assoc., 58 pp.

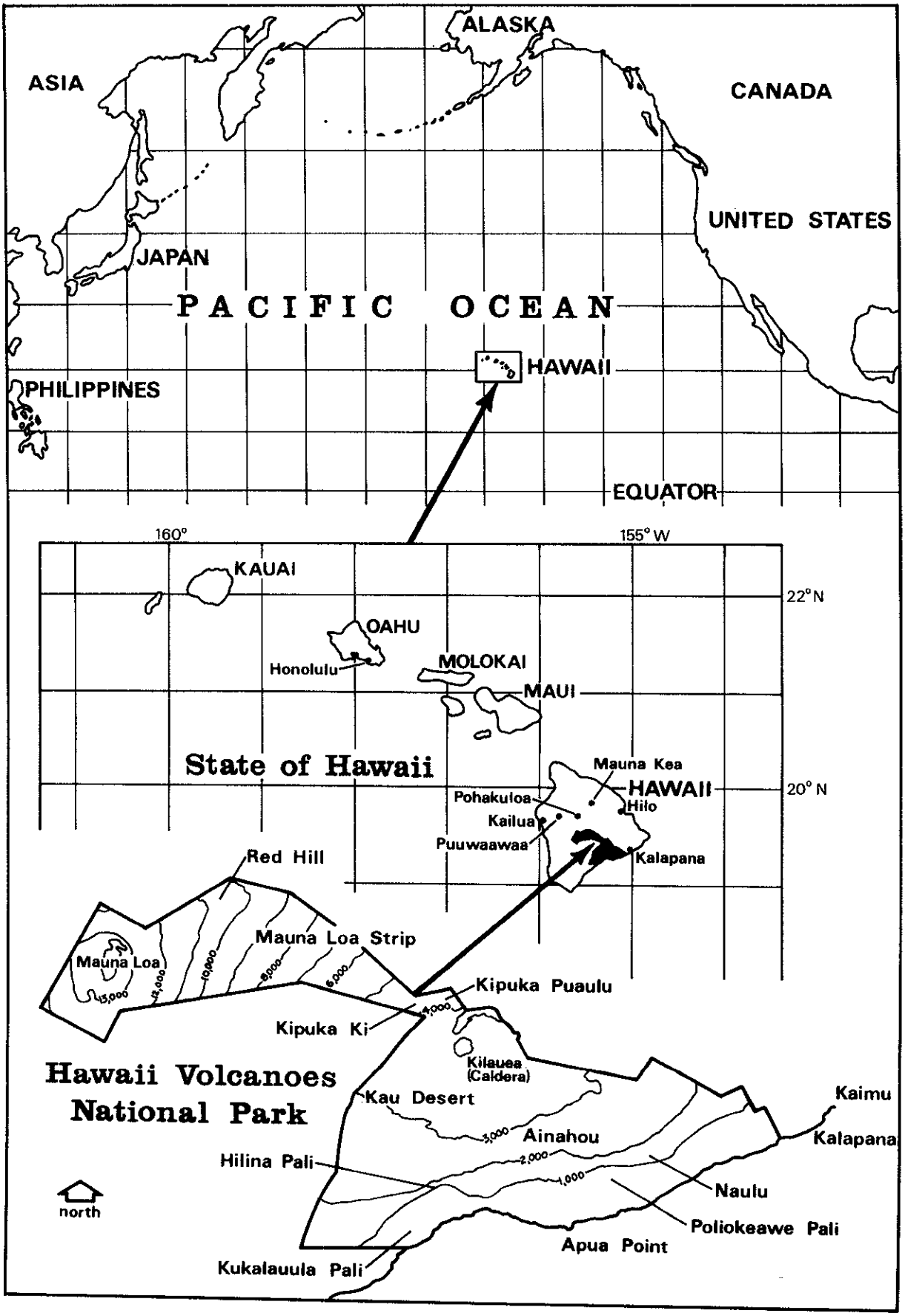


Fig. 7. The location of Hawaii Volcanoes National Park in reference to the State of Hawaii and the Pacific Basin. The Kilauea caldera, approximately circular, is about 3 miles in diameter.

The active volcanoes set repeated fires, and one senses that many native plants have adapted to this--by mechanisms such as sprouts or light, wind-blown seeds. But one also senses that a few newly arrived exotics--broomsedge, fountain grass--are even more successful fire species, and in proper soil and climate they will take over wholesale with repeated fires--shifting native dryland forests to exotic grasslands. Major research is needed to define the role of fire in relation to both native plants and newly arrived exotics.

Kilauea Volcano is also the site of the Hawaiian Volcano Observatory, the oldest and foremost research facility investigating volcanoes. It is a U. S. Geological Survey facility; all geological research projects in the park are coordinated by that agency.

Climate

Steady, moisture-laden trade winds flowing across the topographical barrier formed by the Big Island are the principal cause of climatic variation within the park. In the park on Kilauea's windward side, trade winds dump more than 100 inches of rainfall annually; there rain forests of giant hapuu fern and ohia are luxuriant (Fig. 9b). After crossing Kilauea's summit, the trades are drying winds and the clear sunny skies suck up much of the Kau Desert's 20-inch rainfall. Infrequently, large Pacific storms disrupt the dominance of the trades. Then, for a time, the winds may blow the wrong way; such Kona winds drop the bulk of the rainfall in the lowland Kau. Too, the expected climatic gradient from the hot lowlands to the cold, 13,000 feet summit of Mauna Loa occurs. Treeline is about 7,800 feet.

Biology

> "Like a great museum of geology and island plant and animal life, the Hawaiian Islands lie isolated in the mid-Pacific. Over millions of years this isolation has permitted unique animal and plant phenomena to develop. Natural crossings of vast stretches of ocean by plants and animals in prehuman times are amazing feats of dispersal. After arrival, these organisms, isolated from mainland areas, have taken curious and unexpected courses of evolution, have presented us with the most exciting and astonishing flora and fauna to be found on an archipelago of oceanic islands. About 95 per cent of native Hawaiian plants and animals occur nowhere else in the world--a higher percentage than any comparable area in the world."3/

3/ Carlquist, S. 1970. Hawaii, a Natural History. Amer. Mus. Nat. History, 463 pp.

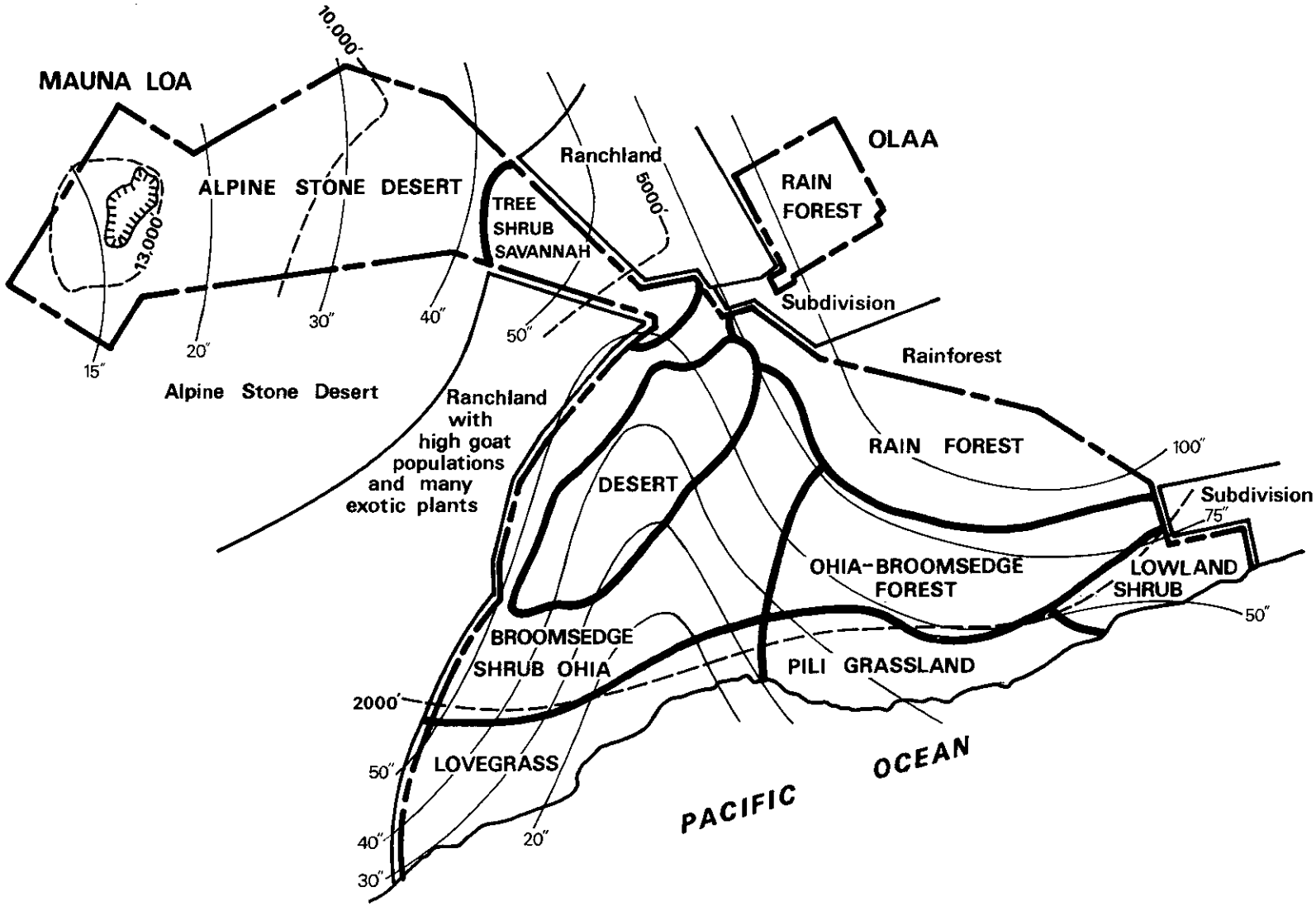


Fig. 8. Existing major vegetation systems. Lovegrass, broomsedge, and most lowland shrubs are exotic.

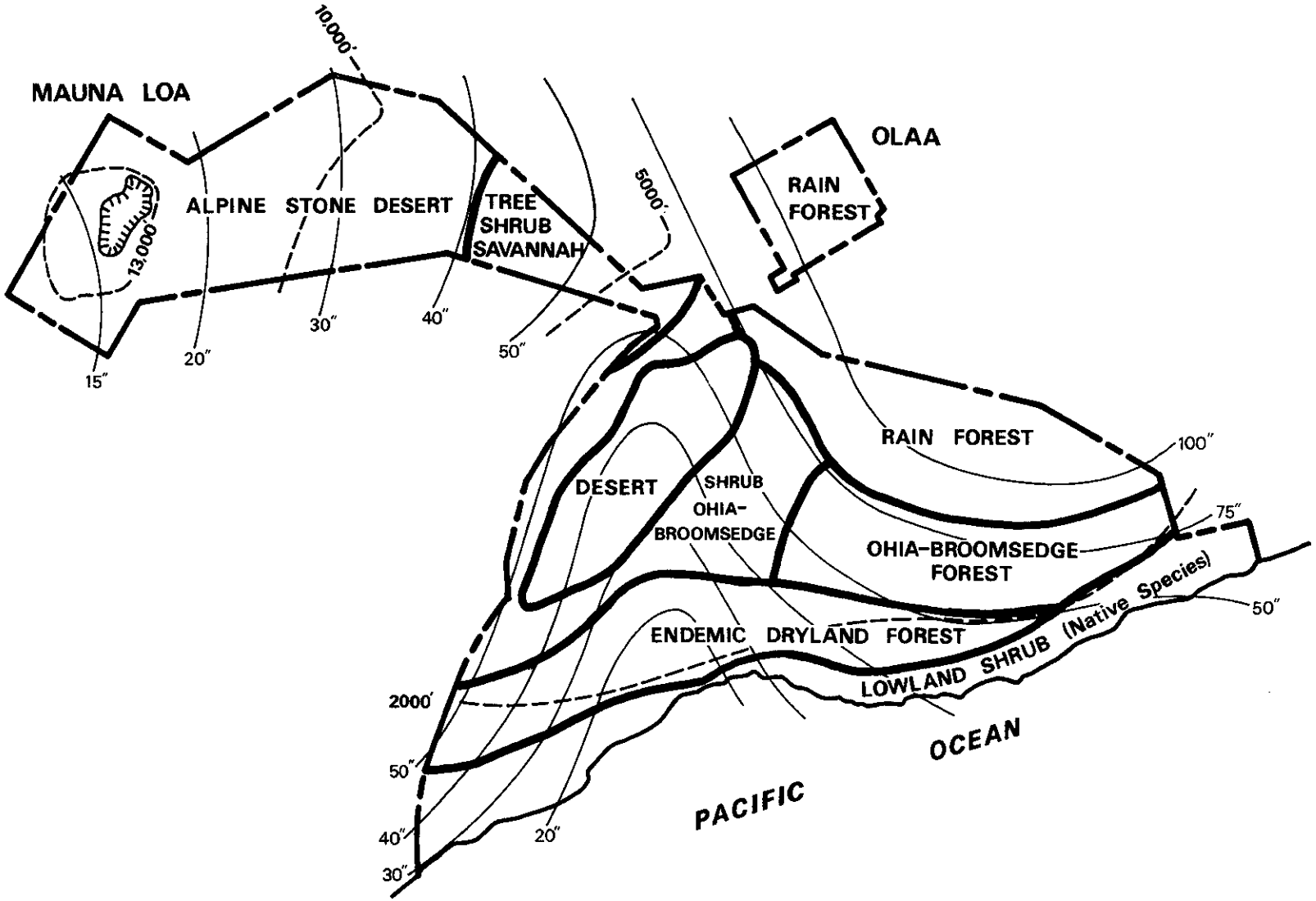


Fig. 9. General anticipated vegetation systems if this plan is followed (zones of lower elevation will largely be native species).

FIG. 9b. On the tradewind side of Kilauea Volcano are exceptionally fine ohia-fern forests.

Hawaii Volcanoes National Park contains an exceptionally fine remnent of this flora and fauna. Of species listed in the park's checklist[4/] of higher plants and vertebrates, 235 plants, 11 birds, and 1 mammal are found nowhere else but Hawaii.

The park offers a substantial biological transect from the stone-desert at Mauna Loa's 13,680 feet summit down through shrub and koa forest savannahs, ohia-fern forest, Hawaiian dryland forests, and low grasslands by the sea. On the Hilo side of this transect--facing the moist tradewinds--are exceptionally fine rain-forests; the Kau side--shielded from the trades--is desert. Figures 8 and 9ashow generalized plant zones. Detailed descriptions and vegetation-type maps are in the park's Atlas for Bioecology.[4/]

Despite being one of the largest and best preserved remnants of endemic Hawaiian natural history, the park has been--and is--suffering incredible biologic losses. The park area and its immediate environs has had twice as many extinctions of bird species as the entire mainland United States. Half the surviving forest birds on the Big Island are listed as "endangered" in the U.S.D.I. Red Book.[5/] If documented, the plant and invertebrate losses would likely appear equally disastrous.

The major cause of decline and extinctions on such a gigantic scale has been the mass introduction of continental species beginning with Captain Cook's release of goats on the Big Island in 1778. The effect of exotic introductions upon isolated island ecosystems is well documented and not peculiar to Hawaii alone. The Galapagos, New Zealand, Australia, and Madagascar share similar biologic tragedy. Hawaii is unique in that losses here are greater.

The number of exotic introductions is huge and continuing. Hawaii Volcanoes National Park has 427 known species of exotic plants--a hundred more than the number of native species. A few species, however, are the most destructive. Goats (Fig. 5) and pigs (Fig. 6) have caused major vegetative type shifts (Fig. 12a). The picture is graphic in illustrating the effect of goats on Hawaiian plants that have been isolated for so long without vegetarian mammals that they have lost all defenses against browsing or grazing. Hawaiian plants lack thorns, thick bark, bad taste, poisons; they are highly palatable, tender, nutritious--and vulnerable.

4/ See footnote 1 on page 17.

5/ U. S.Department of the Interior. 1973. Threatened Wildlife of the United States. Bureau of Sport Fisheries and Wildlife (Resource Publ. #114).

Rats and mongooses are predators that destroy populations of birds that evolved for aeons in the absence of predation. The unpalatable plants Andropogon, faya bush, ekoa, fountain grass, guava, and lantana invade widespread into lands denuded of native plants by goats; the new invaders provide no habitat for Hawaiian birds or invertebrates.

Table 4b. Status of non-native feral mammals in Hawaii Volcanoes National Park, July 1973.

Species	"Guess" Estimate Minimum Number In Park	"Guess" Estimate Maximum Number In Park
Goats	6,000	10,000
Pigs	2,000	6,000
Cattle	20	30
Sheep	20	30
Cats	200	400
Dogs	2	5
Black rats	1/acre	10/acre
Mongoose	1/100 acres	1/acre

Wilderness

Wild lands in the park now under study for classification as wilderness under the Wilderness Act are shown on the Land Classification Map, Figure 10. These have fine wilderness character only in the sense that they are unmarred by man-made developments; but they are profoundly scarred biologically--devastated by goats, pigs, cattle, rats, mongooses, and exotic grasses introduced on the island by modern man. Great acreages bear no resemblance to their pre-modern man wilderness character.

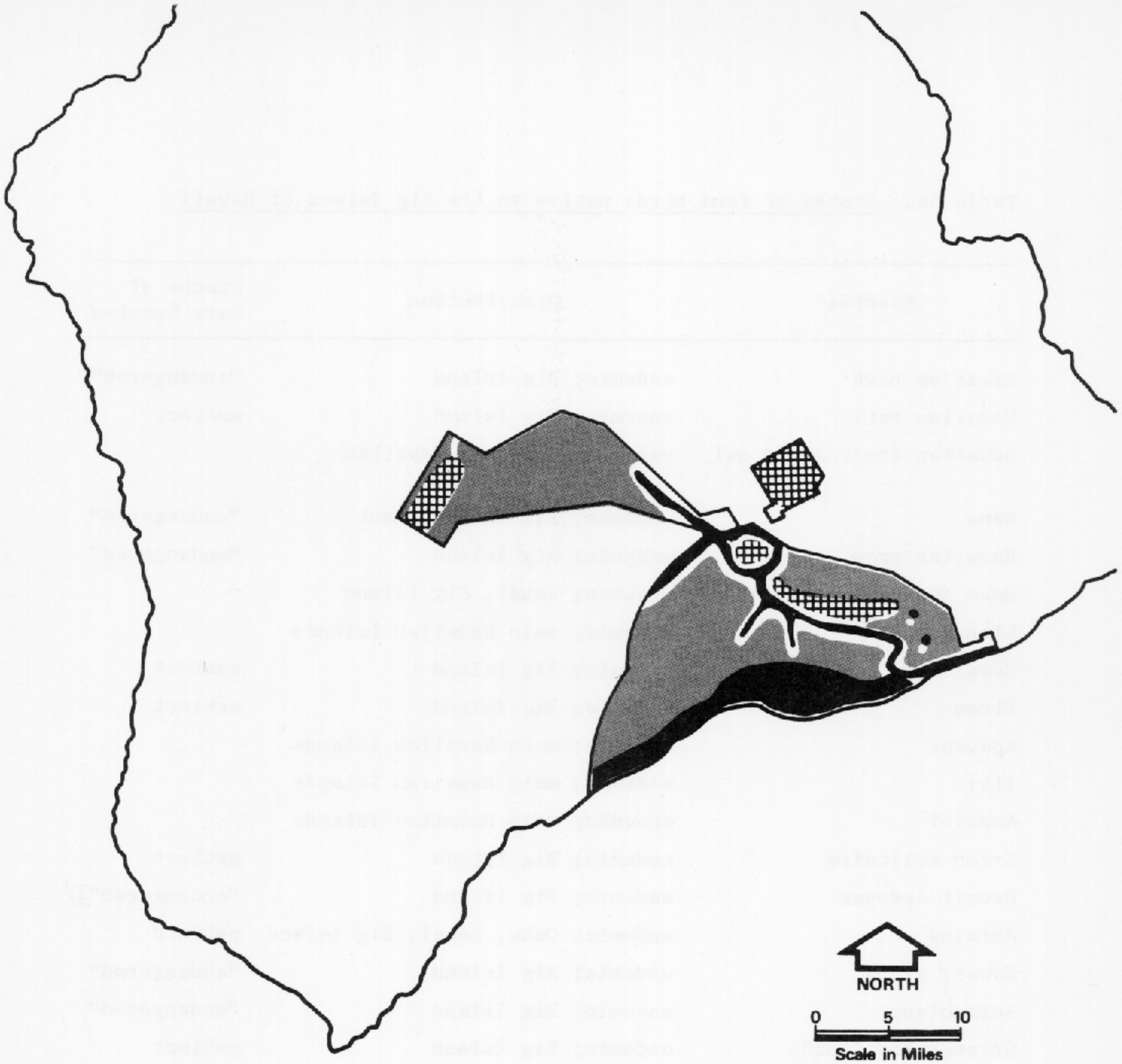
Archeology

The park preserves one of the largest single accumulations of stone structural remains in the Hawaiian Islands and, therefore, is a rich source of research material. Much of the stone remains are, however, unsuitable for the recovery of detailed information. Deposits of habitation material are rare. Only about 9 or 10 sites are regarded as potentially suitable for excavation. The extreme rarity of such sites requires that the utmost care be exercised in their investigation. In fact, it seems clear that some aspects of Hawaiian prehistory can best be investigated only within the park.

Table 5a. Status of land birds native to the Big Island of Hawaii

Species	Distribution	Status of Rare Species
Hawaiian hawk	endemic; Big Island	"endangered"
Hawaiian rail	endemic; Big Island	extinct
Hawaiian short-eared owl	ssp is endemic to Hawaiian Islands	
Nene	endemic; Big Island, Maui	"endangered"
Hawaiian crow	endemic; Big Island	"endangered"
Omao (Hawaiian thrush)	endemic; Kauai, Big Island	
Elepaio	endemic; main Hawaiian Islands	
Hawaii oo	endemic; Big Island	extinct
Kioea	endemic; Big Island	extinct
Apapane	endemic; main Hawaiian Islands	
Iiwi	endemic; main Hawaiian Islands	
Amakihi	endemic; main Hawaiian Islands	
Green solitaire	endemic; Big Island	extinct
Hawaii creeper	endemic; Big Island	"endangered"1/
Akialoa	endemic; Oahu, Lanai, Big Island	extinct
Hawaii akepa	endemic; Big Island	"endangered"
Akiapolaau	endemic; Big Island	"endangered"
Greater koa finch	endemic; Big Island	extinct
Lesser koa finch	endemic; Big Island	extinct
Grosbeak finch	endemic; Big Island	extinct
Ou	endemic; Big Island, Kauai	"endangered"
Ula-ai-howane	endemic; Big Island	extinct
Mamo	endemic; Big Island	extinct
Palila	endemic; Big Island	"endangered"

1/ Hawaii creeper is in as great a danger of extinction as either the akiapolaau or akepa. We expect it to be cited as "endangered" on the Department's next official Endangered Species listing.



LAND CLASSIFICATION

CLASS II – GENERAL OUTDOOR RECREATION

CLASS III – NATURAL ENVIRONMENT

CLASS IV – OUTSTANDING NATURAL

CLASS V – PRIMITIVE

CLASS VI – HISTORIC AND CULTURAL

NONE CLASS I – HIGH-DENSITY RECREATION

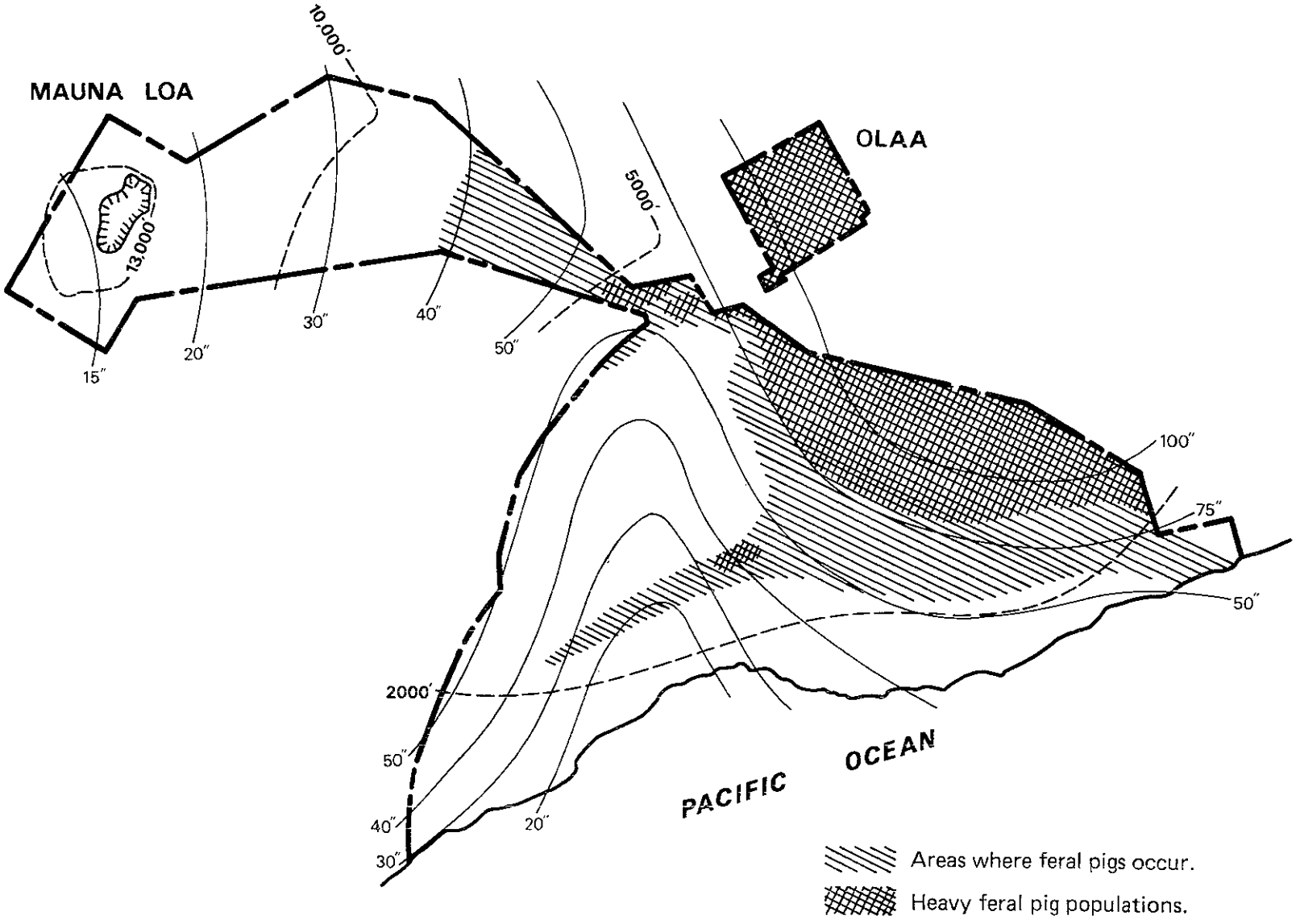
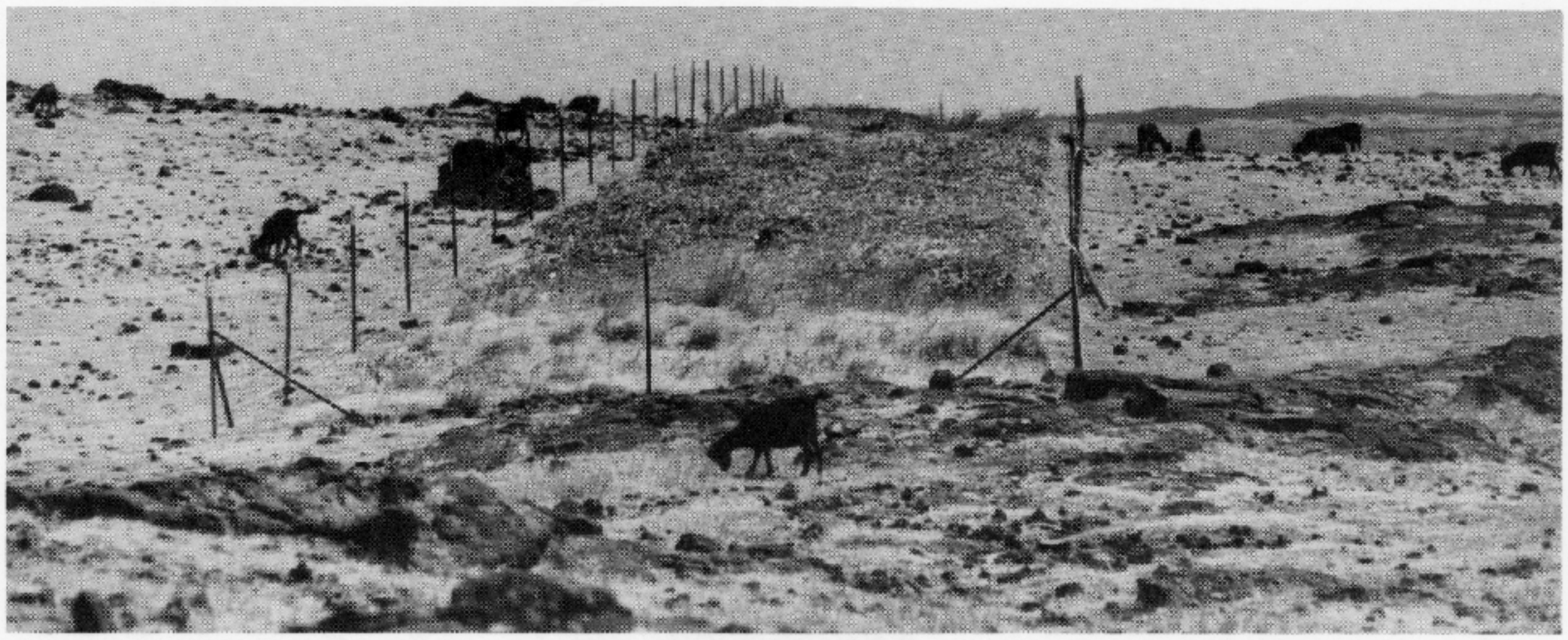


Fig. 11. Distribution of feral pigs in the park.



Species	% Cover OUTSIDE Exclosure	% Cover INSIDE Exclosure
PLANTS NATIVE TO HAWAII:		
Awikiwiki, *Canavalia (kauensis)*	None	45.0
Crabgrass, *Digitaria pruriens*	0.4	23.2
Pili Grass, *Heteropogon contortus*	None	1.2
Wild Portulaca, *Portulaca cyanosperma*	None	Trace
Total Ground Cover by Natives	0.4%	69.4%
EXOTIC PLANTS:		
Lovegrass, *Eragrostis tenella*	20.0	0.6
Burmuda Grass, *Cynodon dactylon*	17.2	18.8
Sedge, *Cyperus compressus*	4.4	None
Molasses Grass, *Melinis minutiflora*	1.6	None
Sedge, *Bulbostylis capillaris*	1.6	None
Spanish Clover, *Desmodium triflorum*	0.4	1.2
Alaalapuloa, *Waltheria indica*	None	2.4
Cassia, *Cassia leschenaultiana*	None	2.4
Total Ground Cover by Exotics	45.2%	25.4%
BARE SOIL AND ROCK	38.0%	None
LITTER	14.4%	None

FIG. 12. Comparison of plant cover inside and outside the Kukalauula Goat Exclosure. Data collected December 1971, 2 years after the exclosure was constructed. Photograph dipicts differences.

FIG. 12b. Pig activity may stimulate the spread of guava, an exotic tree. The seeds are found in pig droppings.

The sections of the Puna and Kau coasts lying within the park are rich in remains of villages, temples, canoe landings, petroglyphs, shelter caves, heiaus, and other evidences of native life. They represent various aspects of ancient and historic Polynesian culture. Sites situated in widely scattered sheltered areas along the rugged Puna Coast were occupied from prehistoric times until the middle 1800's. This sparsely inhabited coast and adjacent upland benches required special adaptation to severe environmental conditions. The people who lived here were mainly fishermen and farmers, and in the uplands some were bird hunters.

Archeological field work was undertaken in 1959 when the Bishop Museum, under the direction of Dr. Kenneth P. Emory,[6/] made an extensive field survey. A second survey[7/] continued the assessment of the park's archeological resources and suggested avenues along which more detailed investigations might proceed. These surveys recorded 380 sites, but there are certainly many more. Between 1962 and 1968 several small sites were salvaged as part of the Chain of Craters Road project.

Wahaula Heiau--Red Mouth Temple--is one of the better known temple sites in the district of Puna. It is reported to have been established and constructed by the foreign chief Paao in A.D. 1275. Kaiiiili Village site adjoins Wahaula and probably supported the temple. Culturally speaking, it is probably the only uncontaminated ruin in the Puna area. It has the distinction of being the only place along the Puna coast where iiiili, small water-polished stones used for paving the temple and the house sites, are found. Moreover, this complex is the most important archeological area in the park and one of the most significant in the Hawaiian Islands, as it is important in the story of Paao and the introduction of the heiau Luakini and the ritual worship of major Hawaiian gods. It is in remarkably fine condition and has an impressive appearance.

Site 911 is a small cave shelter west of Kaiiiili Village near the coast which was used by the ancient Hawaiians as a shelter and an occasional overnight campsite from about A.D. 1300 to modern times.

Kamoamoa Village site represents an area where two periods of time appear to be superimposed. The ancient village appears to

6/ Emory, K. P., et al. 1959. Natural and Cultural History Report of the Kalapana Extension of the Hawaii National Park. Bernice P. Bishop Museum, Part I, 126 pp. and Part II, 67 pp.

7/ Smart, C.D., et al. 1965. The Archeological Resources of Hawaii Volcanoes National Park. Dept. of Anthropology, Bernice P. Bishop Museum. Part I, 110 pp. and Part II, 48 pp.

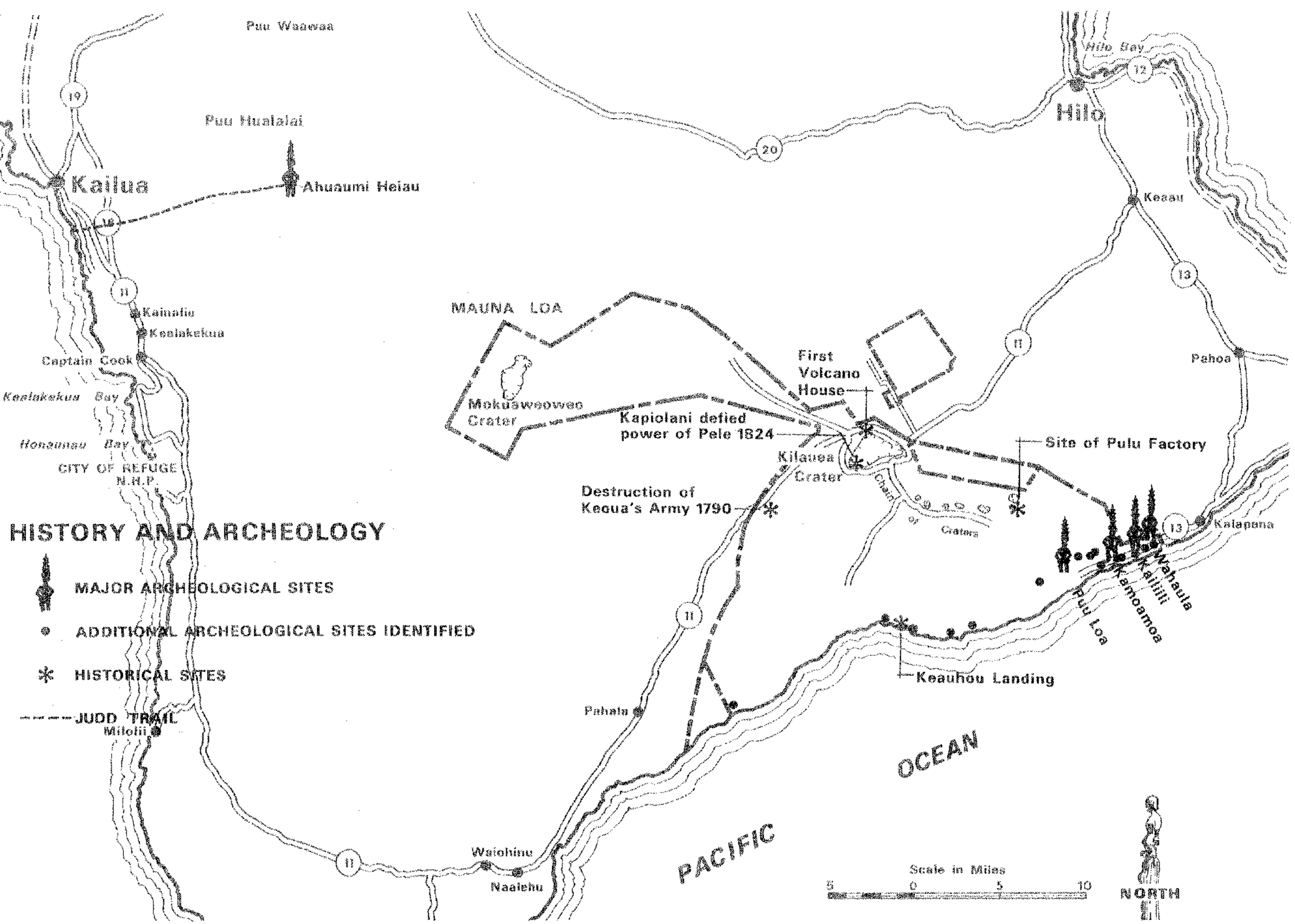


Figure 12c. Major Historic and Archeologic Sites

be farther back from the shore and the later (historic) development is toward the ocean.

The Puu Loa petroglyph field is the largest concentration of "rock carvings" in the park. It is located along an old Hawaiian trail inland from the village of Laeapuki. Many of the petroglyphs are ancient, as they have been almost completely obliterated by successive drawings and erosion. The petroglyph area is about one-half acre, one of the three largest in the Hawaiian Islands.

History

Captain James Cook, R.N., discovered Hawaii for the Western World in 1778 and died at Kealakekua Bay in 1779. His ships, the H.M.S. Discovery and H.M.S. Resolution, in 1779 navigated offshore from what is now Hawaii Volcanoes National Park, trading with the Hawaiians of Puna and Kau, exchanging nails, beads, and cloth for pigs, fruit, and salt.

The historic events that occurred within the park after Captain Cook first viewed the Puna-Kau coast are of value chiefly in their association with events that occurred elsewhere, and in the descriptions of the volcano and the coastal Hawaiian habitation recorded in accounts of early travelers. The destruction by a Kilauea explosive eruption of a portion of Keoua's Hawaiian army in the Kau Desert in 1790, while on its way to battle the forces of Kamehameha, was a factor in the eventual rise of Kamehameha as ruler of all Hawaii. Fossil footprints of some of the Hawaiian warriors still remain today in the Kau Desert.

Kilauea first felt Western shoes in 1823 when a band of Christian missionaries found the summit active and wrote such vivid and widely read descriptions that thereafter Kilauea was of prime scientific interest as well as a desired visitor destination. By the 1840's, before Yosemite Valley had even been discovered, Kilauea Volcano had become a regular stop for tourists to Hawaii. They stayed in native-style huts until, in 1866, a commercial hotel, the Volcano House, was established on the rim. The Hawaiian Volcano Observatory was founded in 1912. Hawaiians held the Kilauea summit sacred, and it was at Halemaumau, the principal vent of Kilauea, that the image of Pele, the volcano goddess, was weakened by the High Chieftess Kapioani. She was a convert to Christianity who defied Pele in 1824 by eating ohelo berries without the traditional offering while also proclaiming the Christian god supreme.

Several relatively recent historic sites have been identified as important. One is the "Old Volcano House" of 1877 which still stands. Another is the Keauhou Landing Site which for a time in

the middle 1800's was a landing for tourists coming to the Kilauea Volcano. The landing and village were virtually destroyed by the 1868 tsunami (tidal wave). A few coconut trees and remains of the old wharf are all that are left of what was once a fairly large village and steamship port.

A third historic site of some significance, a ruin of a factory for producing pulu (a fern product) is located on the trail between Makaopuhi and Napau Craters.

THE LOCAL AND REGIONAL ENVIRONMENT

Land Character

The Big Island--Hawaii--with an area of 4,038 square miles is almost twice the combined size of the other islands in the state. It has generally smooth and gently sloping topography related to the five volcanoes which created the island. The climate is largely the product of the prevailing trade winds, high mountain masses, and elevation. Annual temperature averages a balmy 75 degrees F. at sea level, but freezing winter weather is to be expected on the snowy summits of Mauna Loa and Mauna Kea where elevations exceed 13,000 feet.

The eastern side of Hawaii intercepts the moisture-laden trade winds and favors lush vegetation in humid rain forests and commercial sugar cane fields. The island's northwest coast protected from the trade winds presents a desert appearance with cactus-dotted range land.

Management and planning for Hawaii Volcanoes National Park are affected by the character, ownership, and use of surrounding lands. Barren lava flows at high elevations, and scrub forest below, border the Mauna Loa section. Grazing in the scrub vegetation is the only use of these lands. Grass and scrub range lie west of the park's Kilauea section. Forests are contiguous with most of the eastern boundary. Adjacent lands are primarily under trust estate and State ownership. Between the Kilauea section and the Olaa Forest Tract are estate lands leased for small homesites, agriculture, and a golf course. The balance of the tract is surrounded by forest and grazing lands. There is subdivision activity close to the boundary in the Kalapana section.

Population

The island's civilian resident population in 1971 was about 66,000. Hilo--with half the island's population--is the County seat and the fourth largest city in the State. It is a 40-minute drive from downtown Hilo to the park's center for visitor activities at Kilauea summit. In addition to Hilo, the four largest population

centers on the island are Papaikou (1 hour from the park), Honokaa (2 hours away), Pahala (45 minutes away), and Captain Cook (2½ hours away). The ethnic makeup of the resident population in 1970 was: Japanese, 38%; Caucasian, 29%; Filipino, 17%; Hawaiian, 12%; Chinese, 3%; and others, 1%.

Population trends are reflected in the following table:

Table 12d. Island of Hawaii Resident Population

	1920	1930	1940	1950	1960	1970	Projected 1980	Projected 1990
Number of Residents	64,895	73,325	73,276	68,350	61,332	63,468	84,000-99,000	115,000-137,000

Mainland visitors swell the island's population. Trends in visitors are shown in Table 12e.

Table 12e. Westbound Visitors to the Island of Hawaii

Year	Total Number of Westbound Visitors
1962	75,305
1963	102,025
1964	126,330
1965	161,515
1966	177,665
1967	286,590
1968	369,509
1969	410,697
1970	462,777
1971	522,777

Economic Activity

The island's economic activity is based largely on sugar and tourism, though the island also produces 62% of the beef, 71% of the fruits (other than pineapple), and 36% of the vegetables raised in the State. An indication of the island economic activity is shown in Table 12f of Big Island employment:

Table 12f. Big Island Employment, 1971

Industry	Number of People in the Labor Force
Trade	5,540
State and local government	4,280
Service and miscellaneous (' is hotel)	4,130
Unpaid self-employed, non-agricultural, family workers, and domestics	3,290
Agriculture (½ is sugar)	3,260
Manufacturing (includes 10 sugar mills)	2,800
Unpaid self-employed family workers, agriculture	2,260
Contract construction	1,820
Unemployed	1,740
Transportation, communication, utilities	1,390
Finance, insurance, real estate	910
Federal Government	370
Total Labor Force	31,790

PROBABLE FUTURE OF THE ISLAND'S BIOLOGIC ENVIRONMENT

Even with the proposal the outlook for surviving Hawaiian biota isn't promising. Figures 13 through 38 show remaining distributions of 26 rare and endangered plant species. Figures 39 through 43 show remaining distribution of five rare and endangered birds.

Trends in spread of exotics and changing land patterns outside the park suggest a continuing decline in native ecosystems with gradual transitions from forest land to pasture land and from pure native forest to exotic or partially exotic forests. On the Big Island, areas of the State Department of Land and Natural Resources Natural Areas and the National Park appear to be the only lands where actual management efforts are aimed at protecting native ecosystems.

The State's Natural Areas have a clear objective of preserving native Hawaiian ecosystems. The National Park's mandate is expressed in the August 1, 1916 (39 Stat. 432) Act to establish a National Park in the Territory of Hawaii--"Be it enacted that the tracts of land on the island of Hawaii . . . hereinafter described, shall be perpetually dedicated and set apart as a public park . . . that the said park . . . shall provide for the preservation from injury of all timber, birds, mineral deposits, and natural curiosities or wonders within said park, and their retention in their natural condition as nearly as possible."

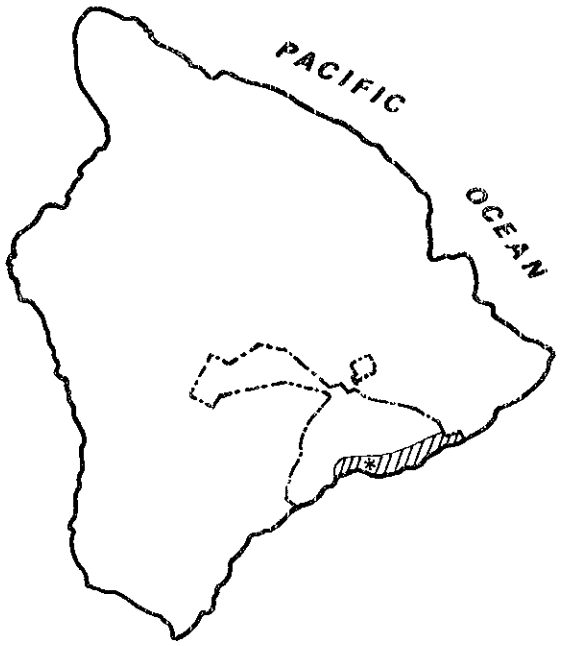
Without this proposal--or alternate proposals with similar goals and potential for success--there is little future for most of the Big Island's endemic biota. Hawaii Volcanoes--a large reserve with both good funding and excellent public support for nature preservation--would be abdicating its responsibility for managing native ecosystems. Conceivably, the Federal abandonment of managing these ecosystems would be contagious--and the State's nature reserves would have a more difficult time securing extensive funding for similar native resource management goals that depended partially upon concurrent actions on the large acreage National Park.

If so, then dozens of endemic plant species on the Big Island would cease to exist as wild, dynamic populations. Hundreds of invertebrate species down the food chain and dependent upon those plants would disappear. Three-quarters of the remaining native forest birds would become extinct. Gradual, but final, vegetative type shifts would change the park's--perhaps the whole island's--plant communities from native Hawaiian forest and savannah lands to exotic, foreign plant associations. Extinction of species are final.

* Present known worldwide distribution.

Anticipated distribution if this proposal is followed.

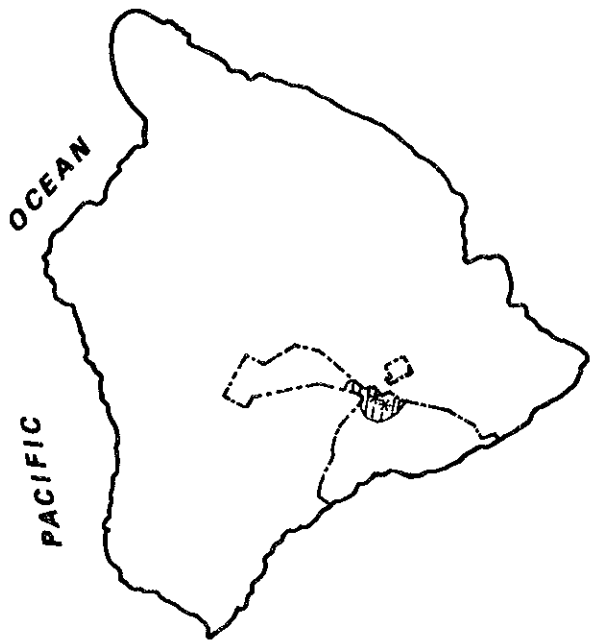
Fig. 13. Range of awikiwiki, *Canavalia kauensis.*



* Present known distribution on Hawaii.

Anticipated distribution if this proposal is followed.

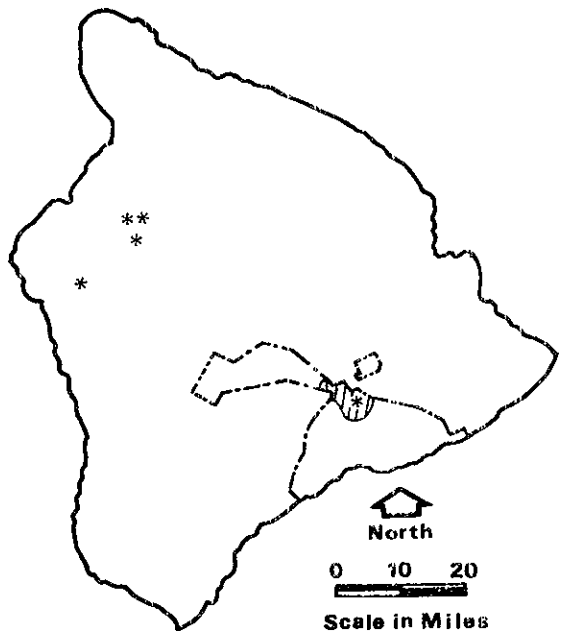
Fig. 14. Range of ohai, *Sesbania tomentosa.*



* Present known worldwide distribution.

Anticipated distribution if this proposal is followed.

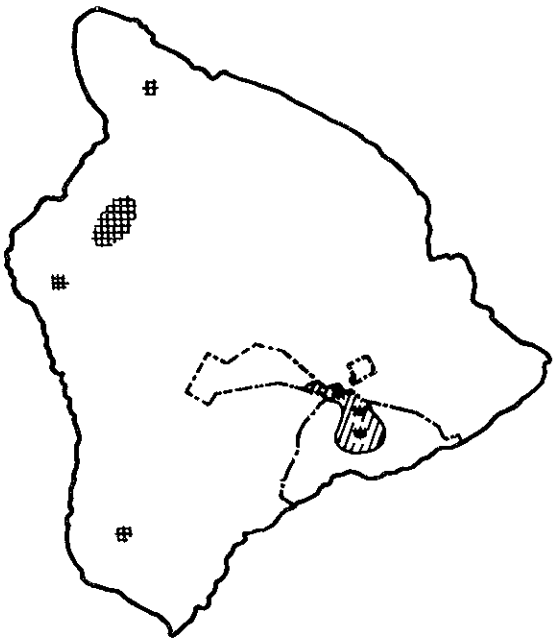
Fig. 15. Range of hau–kuahiwi, *Hibiscadelphus giffardianus.*



* Present known worldwide distribution.

Anticipated distribution if this proposal is followed.

Fig. 16. Range of *Hibiscadelphus hualalaiensis.*



Present known worldwide distribution.

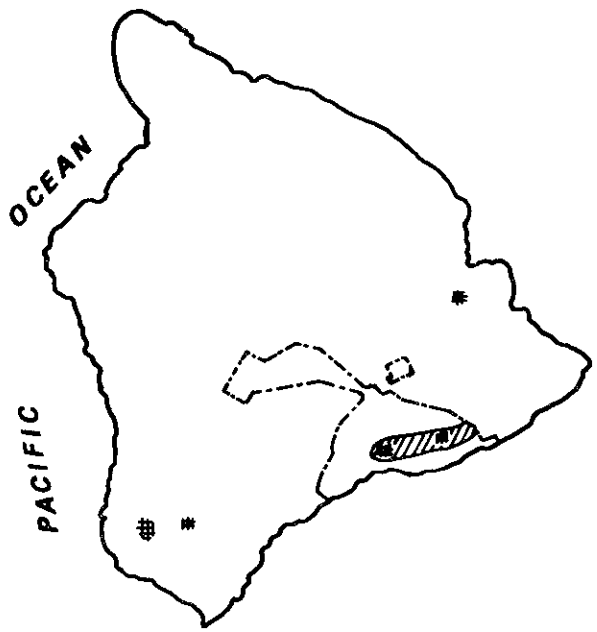
Anticipated distribution if this plan is followed.

Fig. 17. Range of aiea, *Nothocestrum breviflorum.*

Present known worldwide distribution.

Anticipated distribution if this plan is followed.

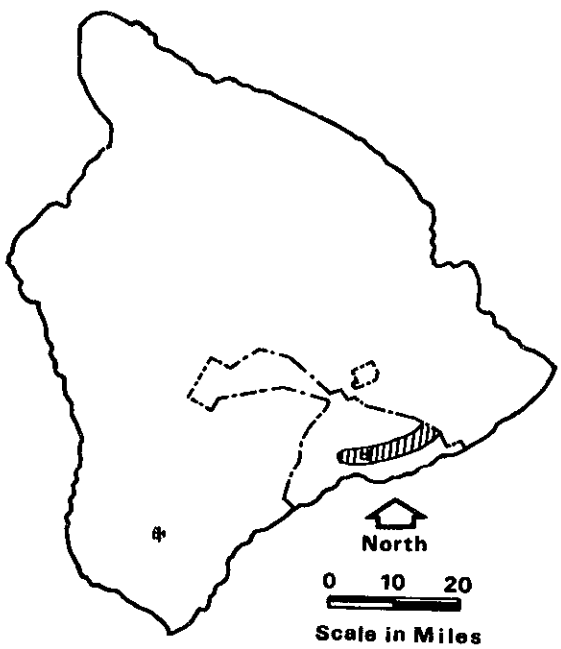
Fig. 18. Range of aiea, *Nothocestrum longifolium.*



Present known worldwide distribution.

Anticipated distribution if this plan is followed.

Fig. 19. Range of ahakea, *Bobea timonioides.*



Present known worldwide distribution.

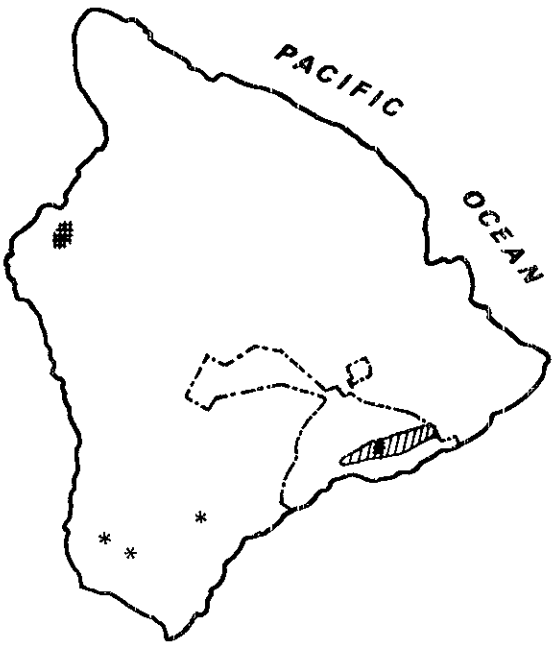
Anticipated distribution if this pro- is followed.

Fig. 20. Range of naupaka, *Scaevola kilaueae.*

* Present known worldwide distribution; known plants.

Anticipated distribution if this plan is followed.

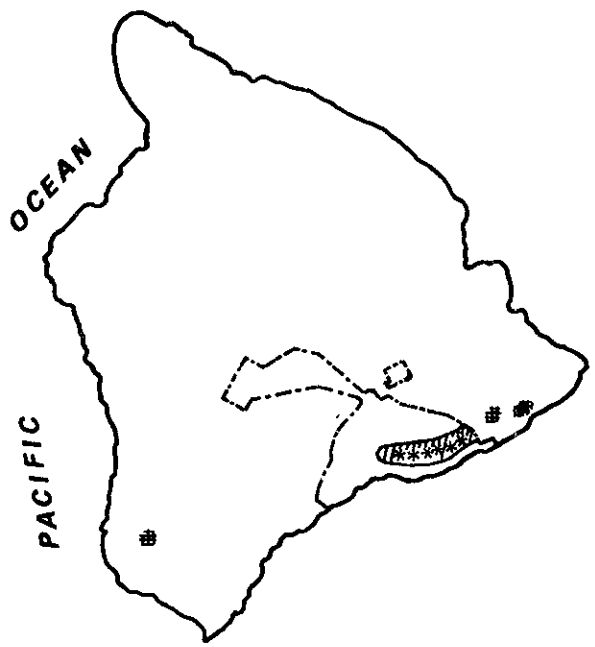
Fig. 21. Range of *Stenogyne angustifolia* var. *angustifolia*.



* Present known distribution on Hawaii (exists on Haleakala, Maui).

Anticipated distribution if this plan is followed.

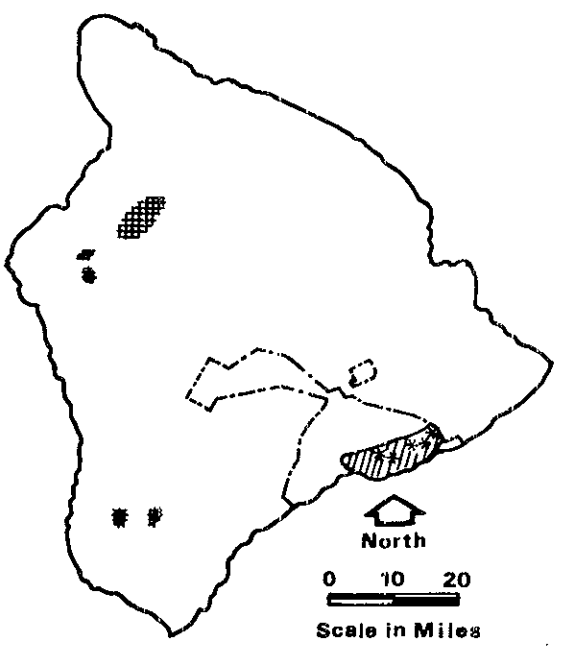
Fig. 22. Range of hame, *Antidesma pulvinatum* on Hawaii Island.



* Present known worldwide distribution.

Anticipated distribution if this plan is followed.

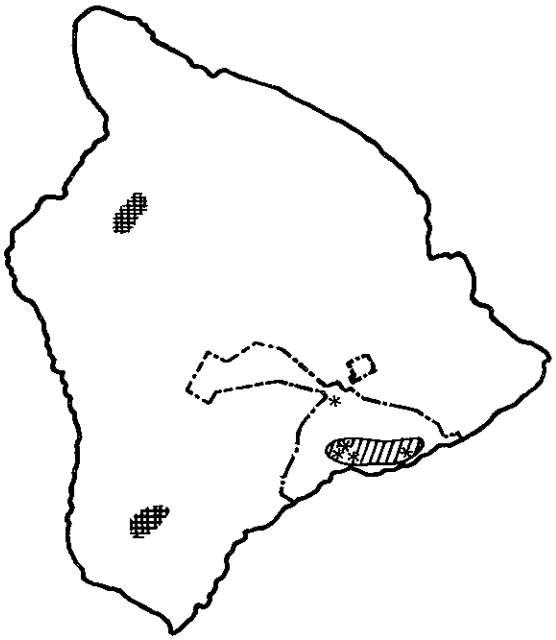
Fig. 23. Range of ohe makai, *Reynoldsia hillebrandii*.



* Present known distribution on Hawaii. Crosses are individual plants. (Exists on Kokee Park, Kauai.)

Anticipated distribution if plan is followed.

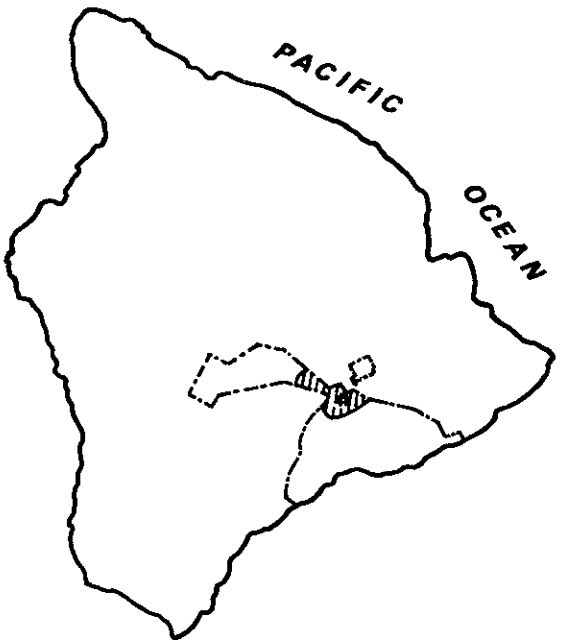
Fig. 24. Range of halapepe, *Pleomele aurea* on Hawaii Island.



* Known plants on Hawaii (occurs also at Kokee, Kauai, and Haleakala, Maui). Crosses are individual plants.

Anticipated distribution if plan is followed.

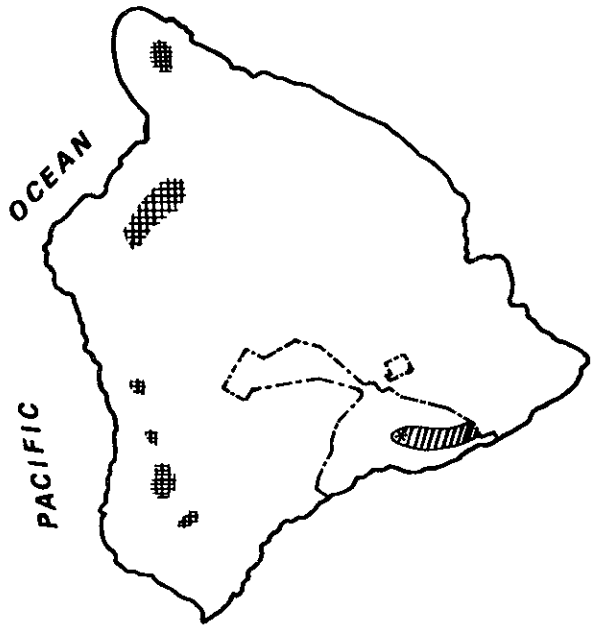
Fig. 25. Range of kauila, *Alphitonia ponderosa* on Hawaii Island.



Present known worldwide distribution.

Anticipated distribution if plan is followed.

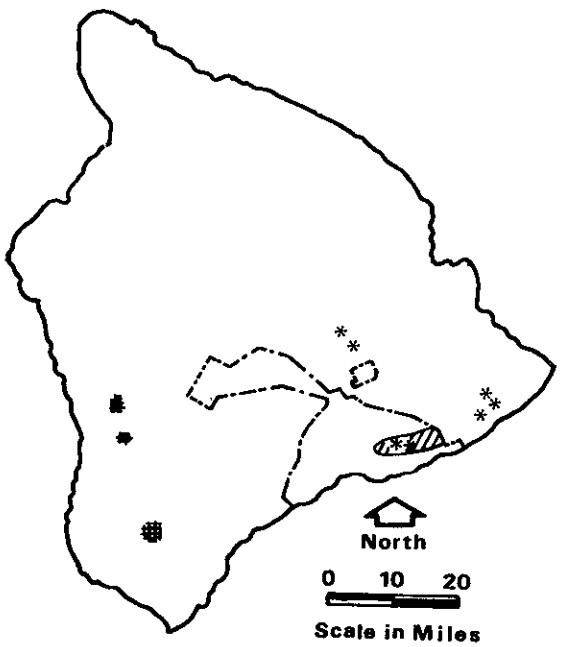
Fig. 26. Range of ae. *Zanthoxylum dipetalum* var. *geminicarpum.*



* Present known worldwide distribution.

Anticipated distribution if this plan is followed.

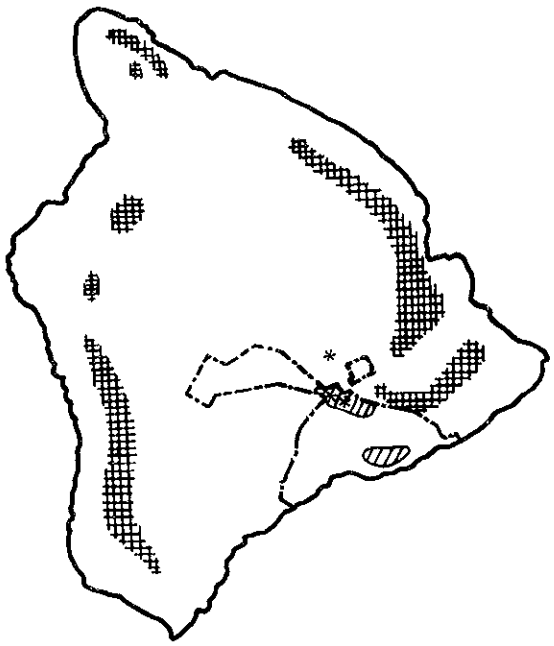
Fig. 27. Range of kului, *Nototrichium sandwicense* var. *macrophyllum.*



* Known plants on Hawaii.

Anticipated distribution if this plan is followed.

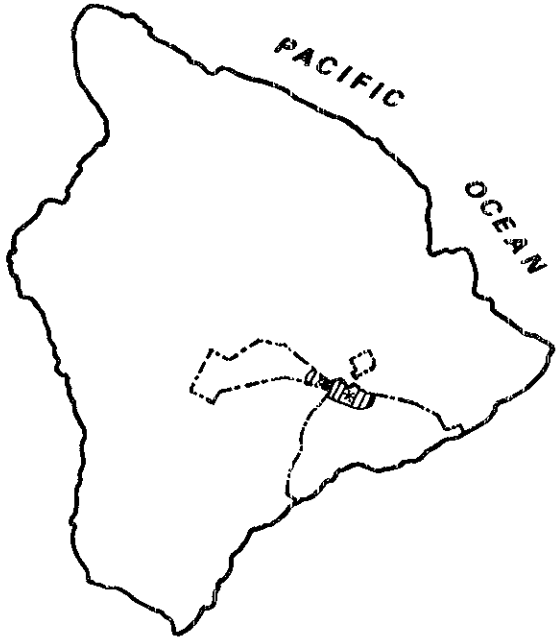
Fig. 28. Range of ohe mauka, *Tetraplasandra hawaiiensis* var. *hawaiiensis.*



* Known distribution (scattered) on Hawaii (still exists on other islands).

Anticipated added distribution in park if this plan is followed.

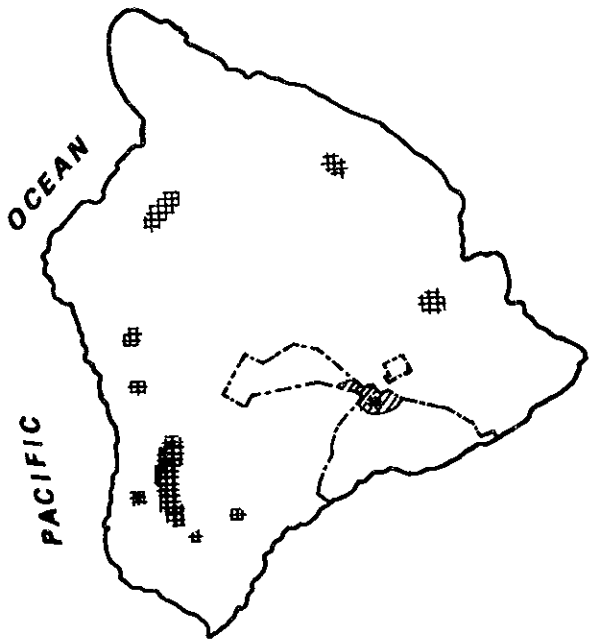
Fig. 29. Range of papala, *Charpentiera obovata* on Hawaii Island.



* Known individual plants on Hawaii (exists also on Haleakala and Kauai).

Anticipated distribution if this plan is followed.

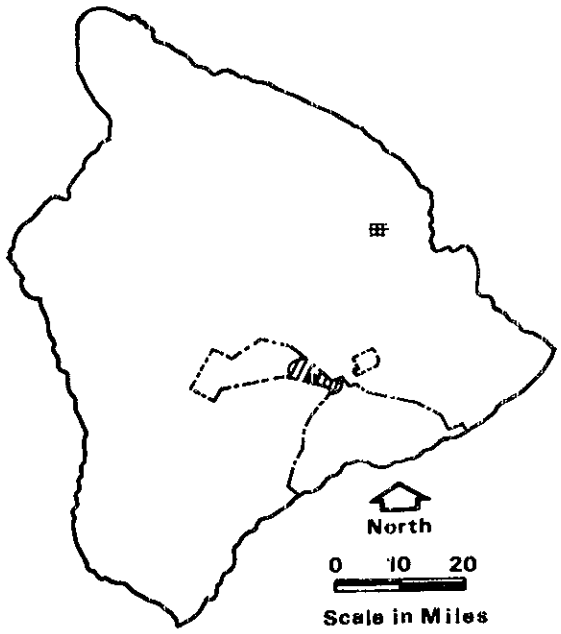
Fig. 30. Range of holei, *Ochrosia sandwicensis* on Hawaii Island.



Present known distribution.

Anticipated distribution if this plan is followed.

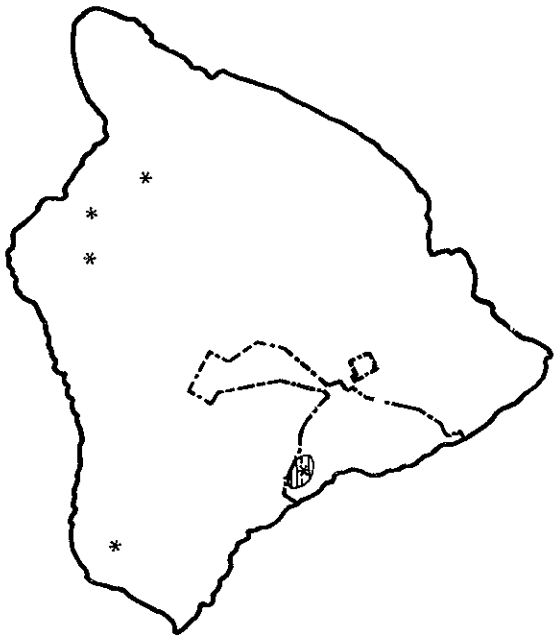
Fig. 31. Range of hoawa, *Pittosporum hosmeri.*



Present known distribution on Island of Hawaii.

Anticipated distribution on Island of Hawaii if this plan is followed.

Fig. 32. Range of silversword, *Argyroxiphium sandwicense.*



* Present known worldwide distribution (known individual plants).

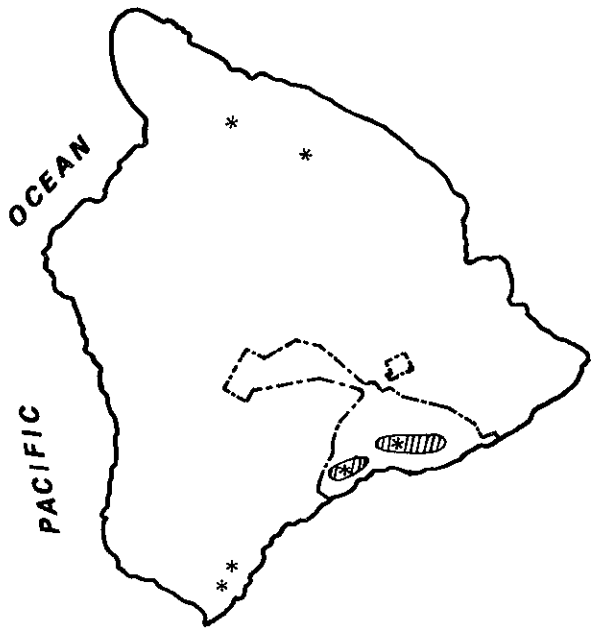
Anticipated distribution if plan is followed.

Fig. 33. Range of oloa, *Neraudia ovata.*

* Present known worldwide distribution (known plants).

Anticipated distribution if this plan is followed.

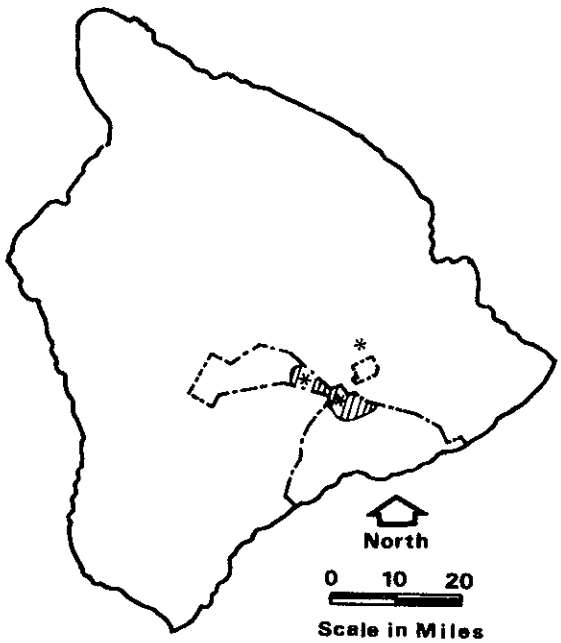
Fig. 34. Range of the tree fern, *Cibotium hawaiiense.*



* Present known worldwide distribution (known individual plants).

Anticipated distribution if plan is followed.

Fig. 35. Range of hao, *Rauvolfia remotiflora.*



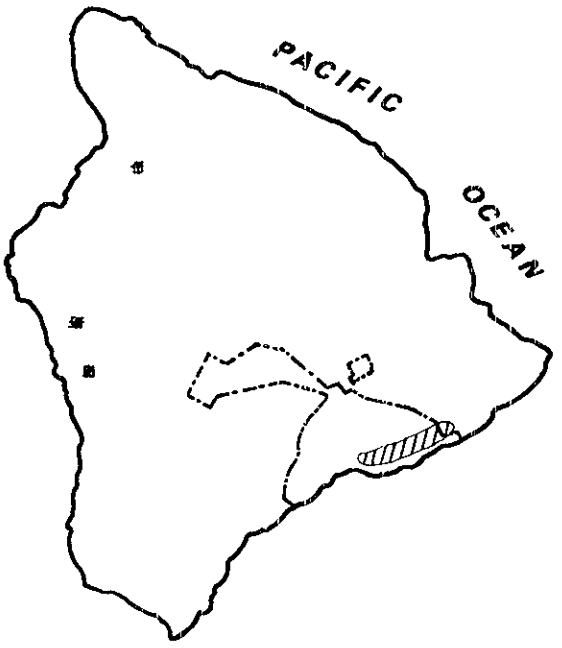
* Present known distribution on Island of Hawaii (known plants).

Anticipated distribution on Island of Hawaii if this plan is followed.

Fig. 36. Range of the ohelo, *Vaccinium pahalae.*

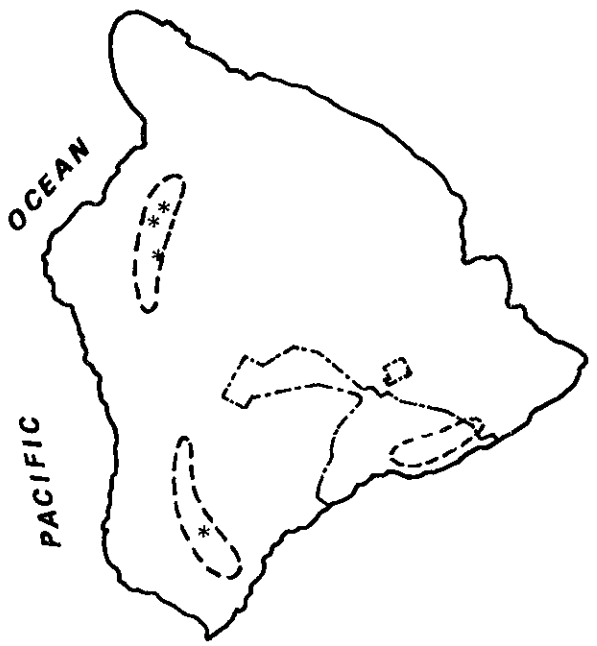
Present location of only known existing plants in the wild.

Speculated former distribution of uhiuhi before cattle and goats were introduced.



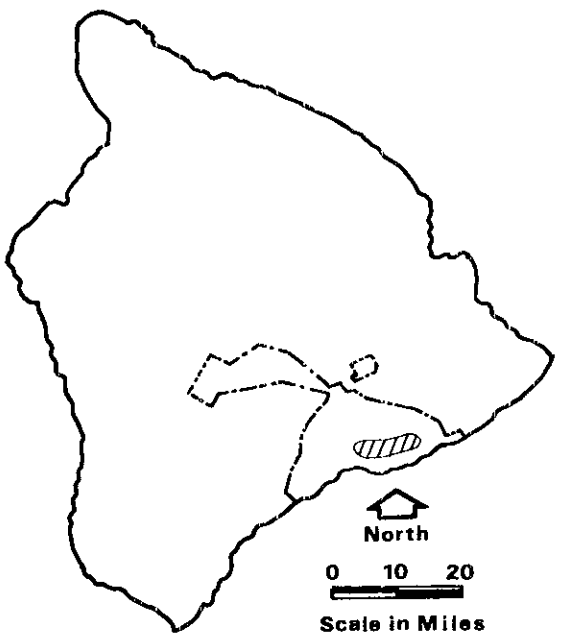
Anticipated wild distribution if this plan is followed.

Fig. 37. Range of uhiuhi, *Mezoneuron kauaiense.*



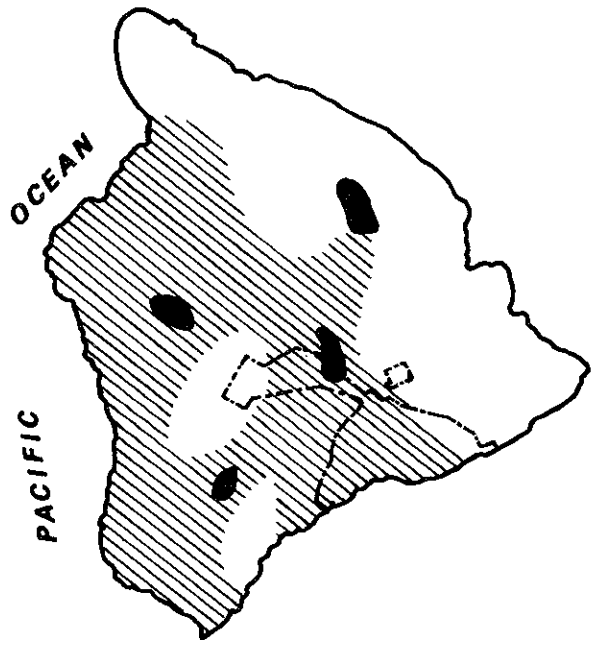
* Present worldwide distribution (known individual plants).

Speculated former distribution of kokio before cattle and goats were introduced.



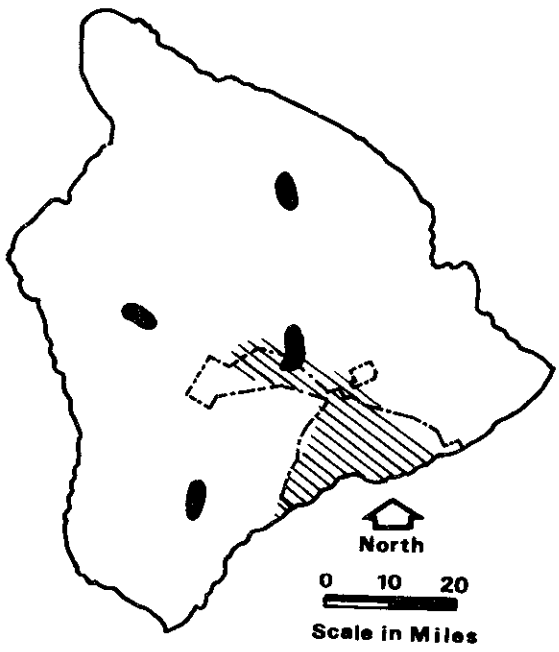
Anticipated distribution if this plan is followed.

Fig. 38. Range of kokio, *Kokia drynarioides.*



Present distribution

Former distribution



Likely future distribution without this plan.

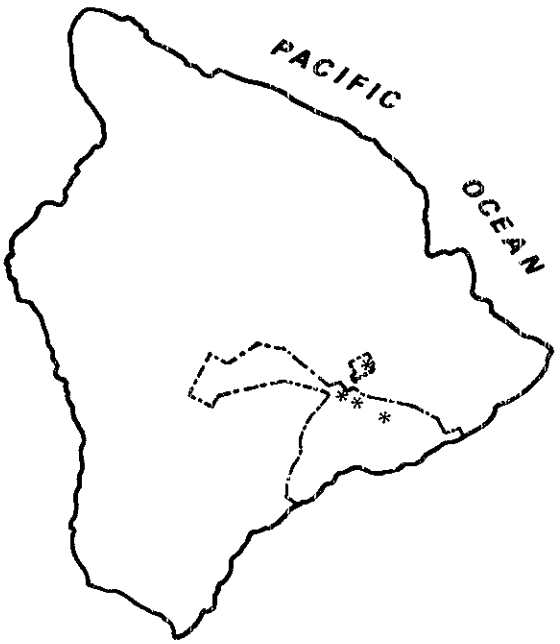
Anticipated additional distribution if this plan is adopted.

Fig. 39. Nene distribution on the Island of Hawaii. A small wild population (artificially supplemented) also exists on Haleakala, Maui. Together these are the extent of the worldwide wild population.

● Location of existing breeding sites on the Island of Hawaii.

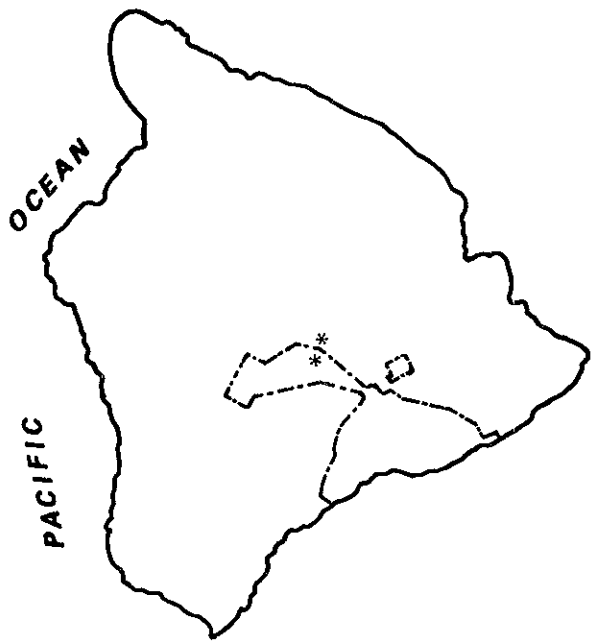
▩ Approximate location of former breeding sites.

Fig. 40. Hawaiian dark—rumped Petrel



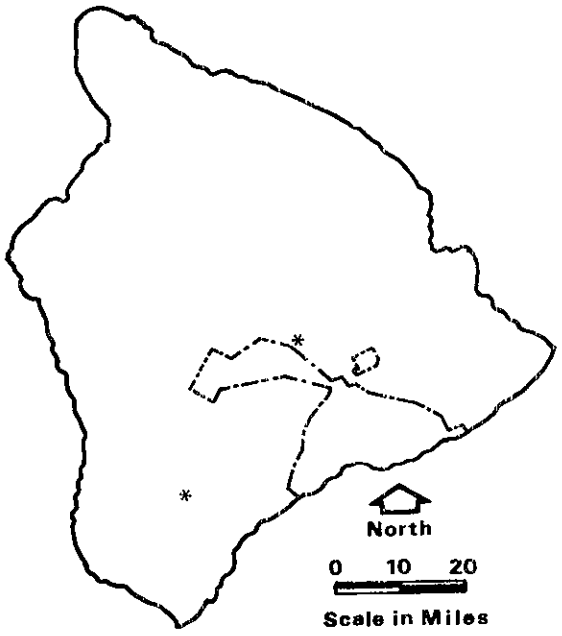
* Location of sightings on Island of Hawaii during last decade.

Fig. 41. Ou



* Location of sightings on the Island of Hawaii over the last decade.

. Akiapolaau



* Location of sightings on the Island of Hawaii over the last decade.

Fig. 43. Hawaii Akepa

ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION

The major impact of this series of actions is that the Park's native Hawaiian organisms and ecosystems will operate under much less influence and destruction of the exotic species introduced by modern man. The environment for at least 15 endangered plant species will be largely restored (Figs. 13 through 38). Habitat for eight endangered birds can begin a recovery process--perhaps in time to save some of these species from extinction. The catastrophic effects of several exotic species--especially goats--introduced by modern man will be greatly reduced. Park visitors will encounter native Hawaiian forests and birds rather than exotic alterations of the environment resulting from pig and goat foraging. In the lowlands, hikers will traverse savannah shrub forests rather than goat-created desert. This is the major impact of the actions--but it will occur only if all the actions are carried off in ecologic harmony.

Other specific impacts vary according to the particular action:

REINTRODUCTION OF PLANTS

Planting operations will cause difficulty to researchers studying plant successions resulting from goat and pig removal--depending upon how widespread the plantings are in terms of acreage affected and species involved. Yet the plantings provide seed supplies for dozens of endemic species now so rare that they will likely never re-establish themselves unaided.

REINTRODUCTION OF NENE

The nene restorations require construction of six fenced pens, each 1 to 2 acres in extent. The pens then will involve 12 acres of the park's 220,000 acres. The pens are not along trails or in areas frequented by visitors; they are inconspicuous to the degree that they are not visible at distances greater than 200 yards from the pens.

CONTROL OF GOATS AND PIGS

Large numbers of goats (currently 4,000 per year) and pigs (500 per year) are taken by a variety of methods.

The Citizen Deputy Ranger Program to remove goats and pigs is offensive to many people who feel that any actions which might imply public hunting in the park should be prohibited.

Aspects of the reduction programs that involve professional Park Rangers shooting goats and pigs irritate many people who feel that

if there is a surplus of goats and pigs, local people should be allowed to take them rather than have any "slaughtered" by rangers.

Commercial goat traders (who purchase live goats from the park at an average of $5/goat and market them at about $25/goat) object to any control effort that diminishes their trade or effectively reduces the herds to levels that threaten a continuing yield.

Fencing (46 miles of interior fencing and 104 miles of park boundary fencing) is permanent. About 30 miles of it lies in areas proposed as wilderness. The Wilderness Study for Hawaii Volcanoes National Park proposes a special provision in the park wilderness ". . . to provide for the use of whatever minimum fences, tools, and equipment that may be necessary to accomplish feral animal control."

Present fence maintenance techniques involve replacement of wire and posts on an average of 20 years--using an all-terrain vehicle (the "Coot" now used leaves no permanent scars on the land) to stretch wire, helicopter to drop in materials, generator-driven electric drill to drill 1-inch post holes in lava, and a 4 to 5-man maintenance crew living in tents. Wilderness designation will prohibit use of the all terrain vehicle but will not deter us from using helicopter, electric drills, etc., because of the special provision in the wilderness proposal. Nonetheless, costs will double from the present fence replacement cost of $5,000/mile for fences in designated wilderness.

Gates are provided where trails intersect fences. Hikers in coastal areas could encounter as many as five fences on an extended trip; on the Mauna Loa Trail they would cross two fence lines. One Trail--the Halape trail--parallels a fence for 2 miles (this fence was built 40 years ago and the trail was worn in by people maintaining the fence; hikers now use it because it is the shortest route to Halape). Efforts to significantly and permanently reduce goat populations have failed repeatedly over the past half century; the simple reason is progress made in goat reductions could not be sustained without adequate boundary and internal fencing. Incredible efforts involving removal of some 80,000 goats are negated when inadequate fencing allows herds to immigrate into goat-free areas.

Direct shooting as a control measure for goats and pigs has not been a safety hazard to visitors to date (Table 5b, page 38b).

CONTROL OF RATS AND MONGOOSES

Rat and mongoose control efforts using traps and Warfarin have no side effects upon Hawaiian hawks, owls, or any native mammal (only the Hawaiian bat is native). Unfortunately--unless research

discovers more effective measures--these control efforts have no widespread impact upon the rat and mongoose populations either. We are only successful in keeping rat and mongoose populations down in the two dozen acres involved in the nene breeding experiments. When, and if, research provides techniques that can be effective in lowering mongoose and rat populations, any proposed use of poisons will require relief from E.O. 11643.

CONTROL OF EXOTIC PLANTS

Exotic plant control is conducted by cutting and painting herbicides on individual stems. The chemicals are approved annually by the Department. The impact of the herbicides extends only to individual plants so treated. The overall effect on the park will be that visitors are more apt to encounter forests of native plants rather than exotics. Native Hawaiian birds will have more suitable habitats and the endangered birds will have greater chance of survival.

None of the actions will place man-made physical developments in the vicinity of archeological features (see Pacific Archeologist Ladd's appraisal, Appendix 2; and Chief Archeologist Scovill's clearance, Appendix 3). No additional fencing is contemplated in the entire Kalapana extension area. In the long run, the native and Polynesian plants favored in the plan are in closer character to the archeological ruins than recently introduced exotics. None of the historical structures that Pacific Historian Apple has nominated to the National Register of Historic Places under EO 11593 lies within miles of any man-made physical developments proposed in this plan. One trail that Apple nominates as historic (the Mauna Loa Trail) is already crossed at right angles by two fences; no more are proposed.

MITIGATING MEASURES INCLUDED IN THE PROPOSED ACTION

Several measures are included in the proposed action to lessen any adverse impacts:

1. Re-introduction of rare plants into former ranges will not be done on a wholesale basis. A variety of local areas will receive plantings--enough to assure survival and potential seed sources of each species. Yet large areas--adequate for scientific studies--will be left without plantings.

2. We have had good rapport with local people who participate in the reduction program. It may be that they will nurture and share our concern regarding Hawaiian hawks, crows, and other Hawaiian birds--so that island-wide mortality by hunters on these species will be less. At any rate, we shall keep close supervision and surveillance of all reduction programs by park employees as well as local citizens.

3. Design and character of the proposed interior fencing will assure that such fencing lies lightly and inconspicuously on the land (Fig. 2). We will avoid straight lines, clear no right-of-ways, and follow the lay of the land. Gates are provided where trails intersect fences.

4. Year-round open seasons on pigs and goats in the Deputy Ranger Control Program assure that there are no unsafe "opening day" crowds or "firing line" situations. As a result, our average number of deputies per day is only six--spread over 140,000 acres open on any given day to deputy control efforts. At an average density of one deputy per 22,500 acres there is little opportunity for conflict between deputies and park visitors. The maximum number of Deputy Rangers that participated on any given day during the last 6 months was 41.

   Goat populations are low along trails, and the deputies generally seek animals off the regular visitor paths. We have the key Halape Trail, Thurston Lava Tube Trail, Puu Loa Petroglyph Trail, Bird Park Trail, and developed areas in safety zones closed to deputies.

   Too, the number of pig deputy ranger parties (parties may not exceed 6 people; average is 2 to 3) is restricted to one party per management unit (average of 3,000 acres each). These parties sign up on a reservation basis to minimize conflicts.

   Table 5b shows the accident record in calendar year 1972. It demonstrates that tighter restrictions and supervision of the Deputy Ranger Program because of its safety record are unnecessary at this time.

Table 5b. Accident record at Hawaii Volcanoes National Park during 1972 related to the Deputy Ranger Program.

	No. of Injuries Related to the Deputy Ranger Program	No. of Injuries Not Related to the Deputy Ranger Program
Total injuries to all park visitors	0	37
Total injuries to visitors on trails or in back country	0	21*
Total injuries to National Park employees	0	2
Total injuries to Deputy Rangers engaged in control work	0	0

* 1 fatality

5. Herbicides are used only by trained employees using biodegradable material given clearance annually by the Department. Poisons are used only in compliance with Executive Order 11643 assuring that any side effects to other organisms are fairly evaluated. (In fact, this is easier in Hawaii where all land mammals other than the bat are exotic.)

6. Current research is providing continuous feedback to modify aspects of the resource management efforts that aren't effective, or are destructive to other values, or to identify new or better approaches. At present Park Service research is concentrated upon determining the effect of pigs on native plants and birds, control of pigs, recovery of vegetation released from goat depredation, and propagation of rare Hawaiian plants. The Park Service also makes available housing to a Bureau of Sports Fisheries and Wildlife biologist studying native Hawaiian forest birds and to International Biological Program biologists studying all aspects of island ecosystems.

7. No man-made physical developments will be placed in vicinity of archeological features (see Pacific Archeologist Ladd's appraisal, Appendix 2; and Chief Archeologist Scovill's clearance, Appendix 3). None of the historic structures Pacific Historian Apple has nominated to the National Register of Historic Places under EO 11593 lies within miles of any man-made physical development proposed in this plan. One trail that Apple nominates as historic (Mauna Loa Trail) is already crossed at right angles by two fences; no more are proposed.

ADVERSE EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSAL BE IMPLEMENTED

Though the effects of this series of actions are beneficial to the preservation of native Hawaiian biology, and regardless of the mitigating measures discussed previously, there are incidental adverse effects to other public values. These are:

1. Where rare plants of the species the park is propagating become established in the areas defined as planting zones, researchers will be unable to determine if these resulted from park operations or natural processes.

2. There is objection to the deputy ranger pig and goat control because of fears that this will evolve into a sport hunting program with an objective of sustained annual yield of goats and pigs from managed high goat and pig populations--at the expense of the native biota.

3. As numbers of pigs and goats are depressed to levels allowing survival of Hawaiian plants, the remaining pig and goat populations will be generally unproductive for deputy ranger harvest. Also, commercial goat traders (who purchase surplus live goats from the park at an average price of $5 and market them for an average price of $25) will find the park unproductive as a source of goats.

4. Forty-six miles of interior fences--however inconspicuous--will exist in the park. About 30 miles of this fence lies within areas proposed as wilderness. The Wilderness Study for Hawaii Volcanoes National Park proposes a special provision in the park wilderness ". . . to provide for the use of whatever minimum fences, tools, and equipment that may be necessary to accomplish feral animal control."

THE RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The greatest benefits to be derived from an adequately managed Hawaii Volcanoes National Park are scientific in that if these disappearing endemic plant and animal communities can maintain even a semblance of their original integrity the information thus available can help indicate how other portions of our environment can be similarly maintained. This is especially significant in Hawaii because of the vulnerable nature of these ecosystems--complex insular biotic communities that developed somewhat independently of continental lifeforms but sensitive to competition from those same lifeforms.

If these resources can be maintained, the inspirational and educational opportunities for the public are legion. The dramatic displays of volcanism and their myriad opportunities for interpretation and research will continue despite man's operations. Many of the native birds and some rare plants, however, simply will not continue to exist without some positive management program that seeks to protect them.

The few adverse effects--undesirable aspects of goat and pig removal efforts, and visual intrusion of fences in wilderness--are far outweighed by long-term benefits to accrue to all people over all time by actions to preserve and restore the park's native biology.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION

The proposed actions are aimed at preventing irreversible and irretrievable losses of Hawaiian biota including the extinction of several birds and some two or three dozen higher plants.

The proposed actions can be halted at any time--fences removed; pig, goat, and exotic plant control abandoned--and the exotic pig, goat, guava, lantana, faya bush associations will quickly re-invade.

No non-renewable resources (landforms, archeologic sites, historic sites) will be altered by this plan.

ALTERNATIVES TO THE PROPOSED ACTION

During long-standing natural history research efforts and management programs, many alternatives to the proposed actions have been considered and tried. Fundamental alternatives relate to the basic definition of objectives to be accomplished. Table 6 presents an evaluation of the park objectives compared to other possible alternative goals in preserving and managing the park's biotic resources.

If content with the statement of park purpose and objectives, there are many further alternatives to each facet of a resource management effort. Separate analysis by topic does not infer that these different components of the resource are unrelated. In fact, all aspects of the resource plan are as interdependent as a house of cards.

A. Alternatives in plant restoration are discussed in Table 7.

B. Alternatives related to methods for re-introducing rare and endangered birds (other than the nene) into recovering habitat must await continuing research. Present knowledge of the honeycreepers and the Hawaiian crow is inadequate to plan restoration efforts.

   The following alternatives were considered in planning re-introduction efforts with the nene:

   1. Do nothing. This is the most reasonable approach if the present proposal jeopardized the remaining population of nene. It doesn't. The number of birds involved with the program is a dozen; these are birds raised in the artificial breeding program at Pohakuloa.

   2. The proposed program disturbs very little area. It wastes no nene, and has a reasonable potential of raising young nene imprinted to a natural rather than a caged environment. It complements the State nene program at Pohakuloa by extending propagation efforts into native Hawaiian ecosystems.

   3. A greatly expanded propagation effort seems an unnecessary duplication of the State Department of Land and Natural Resource program at Pohakuloa.

C. Alternatives in goat control are discussed in Table 8.

D. Alternatives related to pig control are similar to those for goats except that pig-proof fences are not feasible, pig population control is much more difficult, and knowledge of pig ecology and population dynamics is more limited than for goats. Based upon present knowledge, the following pig control alternatives have been considered:

1. Do nothing about pigs. Research efforts now underway show that pigs are a major factor in the destruction of native plant environments.1&2/

2. The present program involving hunting pigs by both a citizen deputy ranger program and paid Park Service hunters does minimum environmental damage and depresses the pig populations. It is not lowering the pig population in remote rain forest areas to the extent that native plants are unaffected by pigs.

3. Expand the present program to use widespread poisoning and/or birth control chemicals. Our present knowledge is inadequate to evaluate if such techniques would really lower pig populations and if they would have side effects upon such species as the endangered Hawaiian hawk or affect domestic animals adjacent to the park. A research effort within the Mauna Loa Strip goat exclosure is planned to explore both pig control techniques and the ecological side effects. This research will allow better evaluation of this pig control alternative.

E. There are no known methods of rat and mongoose control that effectively limit populations to low levels over widespread wild lands and that may not cause biological damage to other organisms. Quite simply, this limits the available alternatives at hand now to the program of continuing intensive trapping and poisoning in very delimited acreages around the nene breeding enclosures and petrel nesting sites.

F. Alternatives to the present measures in exotic plant control include:

1. Expand the number of species involved. The list of species presently controlled is based upon evaluations of whether techniques are possible, the damage potential of the species, and cost/benefit anticipation of the control. The plants proposed for control seem the highest priority. Yet, there is good logic in expanding the number of species involved.

2. Do not control exotic plants. Such an approach would lead dramatic type shifts in the case of ekoa, faya bush, fountain grass, and others. Perhaps in time, with a complete absence of

1/ Spatz, G. and D. Mueller-Dombois. 1972. Succession patterns after pig digging in grassland communities on Mauna Loa, Hawaii. Island Ecosystems IRP; U. S. International Biologic Program Technical Report #15, 44 pp.

2/ Mueller-Dombois, D. and C. H. Lamoureux. 1967. Soil-vegetation relationships in Hawaiian kipukas. Pacific Science 21(2): 286-299.

goats, natural succession might allow Hawaiian plants to replace these. The odds are slim when considering the potential of the exotic plants listed in Table 4a.

Table 6. Alternatives related to the purpose and objectives in managing the park's natural history resources.

Alternatives within the framework of legal authority expressed in the Act of 1916	Effect upon the park's scenic beauty for public appreciation and enjoyment	Effect upon preserving geologic features for public appreciation and understanding	Effect upon preserving archeological features for public understanding and enjoyment	Effect upon endemic Hawaiian organisms and ecosystems	Dollar costs
A. This plan: The purpose and objectives of park management are to preserve and restore the park's organisms and ecosystems that are native to this park; i.e., that are typical of Hawaii prior to the environmental modifications attributed to modern man during the period beginning with the arrival of Captain Cook.	Scenery would be picturesque and unique. Vegetation would have the integrity of being native and typically Hawaiian. It would be an exceptional example of the natural Hawaiian scene.	No effect	Archeologic ruins would be associated with native Hawaiian species.	This alternative would allow preservation and restoration of the park's major Hawaiian vegetation types. Endemic Hawaiian species dependent upon these plant communities would have habitats.	Considerable but not impractical.
B. Modify the stated purpose and objectives of park management. Focus efforts to conserve all living things in an environment where natural processes (including new organisms' invasion of islands, natural selection, species extinctions, evolution of new vegetation communities) are dominant and free of man's intervention. With this objective we would allow any living thing--Hawaiian and introduced--to compete for a place in the park's space.	The scenery would be picturesque but the vegetation would not have the integrity of belonging to Hawaii. (An analogy--Yosemite Valley would still be beautiful with picturesque groves of eucalyptus rather than the natural groves of California black oak and ponderosa pine.)	No effect	Archeologic ruins would be associated with foreign plant communities and species.	This alternate would assure the destruction of the remaining Hawaiian communities in the park. It would allow extinction of some two dozen Hawaiian species within the next few decades.	Minimal

Table 7. Alternatives related to plant propagation and re-introduction into former range.
(Discussion of these alternatives is based upon the premise that exotic goats, pigs, and plants are controlled).

Alternative	Feasibility of this alternative	Effect of this alternative upon attaining the park objectives of preserving native ecosystems and re-establishing the park's endemic species into their former ranges.	Effect of this alternative upon saving the park's rare and endangered plants from extinction in a natural, wild state.	Effect of this alternative upon existing and potential studies relating to plant succession and distribution.
1. Make no plantings.	Feasible	Park ecosystems will probably always lack many of the species listed in Tables 2 and 3--as well as organisms dependent upon those specific plants.	Most species listed on Tables 2 and 3 will never become re-established as wild, dynamic populations.	Vegetation studies are uncomplicated by deliberate plantings.
2. Limit plantings to a few, small acreage, arboretum-type sites.	Feasible	Park ecosystems will probably always lack many of the species listed in Tables 2 and 3--as well as organisms dependent upon those specific plants. The opportunity for more widespread planting would not be lost--this alternative saves seed sources.	Most species listed on Tables 2 and 3 will never become re-established as wild, dynamic populations The opportunity for more widespread planting would not be lost--this alternative saves seed sources.	Vegetation studies are uncomplicated by deliberate plantings.
3. Limit plantings to only those seedlings that are individually marked or labelled and surveyed as to location.	This is an overwhelming task; it would not be feasible even with unlimited funding.	Park ecosystems will probably always lack many of the species listed in Tables 2 and 3--as well as organisms dependent upon those specific plants. The opportunity for more widespread planting would not be lost--this alternative saves seed sources.	Most species listed on Tables 2 and 3 will never become re-established as wild, dynamic populations The opportunity for more widespread planting would not be lost--this alternative saves seed sources.	Vegetation studies are uncomplicated by deliberate plantings.
4. This proposal; plant a delimited number of carefully selected species in areas recorded by mapped zones of plantings. (These zones comprise about 25% of the species' suitable range in the park.)	Feasible	Has a high chance of success in preserving ecosystems that include most rare Hawaiian plants that are natural components of the park's biota.	Has a high chance of success in preserving the species listed in Tables 2 and 3.	Studies are moderately complicated by planting programs on those areas mapped as planting sites.

Table 7. Alternatives related to plant propagation and re-introduction into former range. (Continued)
(Discussion of these alternatives is based upon the premise that exotic goats, pigs, and plants are controlled).

Alternative	Feasibility of this alternative	Effect of this alternative upon attaining the park objectives of preserving native ecosystems and re-establishing the park's endemic species into their former ranges.	Effect of this alternative upon saving the park's rare and endangered plants from extinction in a natural, wild state.	Effect of this alternative upon existing and potential studies relating to plant succession and distribution.
5. This proposal--except do not plant rare species suspected of once occurring in the park (listed in Table 3).	Feasible	Has a high chance of success in preserving ecosystems that include the rare Hawaiian plants listed in Table 2. Park ecosystems would lack rare plants listed in Table 3.	Has a high chance of preserving species listed in Table 2. Plants listed in Table 3 would not be found in this park; they might not survive elsewhere in as a wild population.	Studies are moderately complicated by planting programs on those areas mapped as planting sites.
6. This proposal, except expand the area of planting to include all suitable range.	Feasible	Has a high chance of success in preserving ecosystems that include most of the rare Hawaiian plants that are natural components of the park's biota.	Has a high chance of success in preserving the species listed in Tables 2 and 3.	Studies are highly complicated by the planting programs.
7. This proposal; plus expand the number of species planted to include several of the park's rare species, but that have puzzling or questionable taxonomy or distributions (Appendix 1).	Feasible	Has a high chance of success in preserving ecosystems that include most rare and endangered plants known to be native to the park. This alternative may spread several species well beyond their natural niches or cause unnatural hybridization of some species.	Has a high chance of success in preserving the species listed in Tables 2 and 3. This alternative may cause unnatural hybridization of some species (Appendix 1).	Studies are complicated by planting programs on those areas mapped as planting sites and by planting programs contributing to plant hybridization.

Table 7. Alternatives related to plant propagation and re-introduction into former range. (Continued)
(Discussion of these alternatives is based upon the premise that exotic goats, pigs, and plants are controlled).

Alternative	Feasibility of this alternative	Effect of this alternative upon attaining the park objectives of preserving native ecosystems and re-establishing the park's endemic species into their former ranges.	Effect of this alternative upon saving the park's rare and endangered plants from extinction in a natural, wild state.	Effect of this alternative upon existing and potential studies relating to plant succession and distribution.
8. This proposal, plus expand the number of species planted to include rare and endangered species that may never survive outside the park in wild populations--but that were never presumed to have occurred in the park (Appendix 1).	Feasible	Ecosystems began to be atypical of the park even though they involve endemic Hawaiian species--depending upon the number of species involved in the plantings that were never native to the park.	Has a high chance of success in preserving species in Tables 2 and 3 as well as rare species not native to the park but that now still exist in Kau and Kona districts of Hawaii (Appendix 1).	Studies are highly complicated by the planting programs.

Table 8. Alternative techniques in controlling goat populations at a low enough level to protect the park's remnant Hawaiian ecosystems from further depredation and competition by goats.

Alternative technique	Can this technique alone effectively reduce and maintain a low enough goat population that endemic plants are not affected by goats	If used with other techniques--can this help to effectively reduce and maintain a low enough goat population that endemic plants are unaffected	Effect upon scenic environment	Effect upon park wilderness designation	Social or other consideration
1. Do nothing to control goat populations.	No	No	Goats would browse the park's dryland habitats into sterile deserts. Great numbers of species would be lost. The changes would be irreversible and permanent.	Wilderness would be merely an area devoid of fences and roads; its natural ecology would be totally foreign to Hawaii.	Public who trust that the NPS will make every reasonable effort to preserve Hawaii's endangered species would be appalled at this approach.
2. Build and/or maintain 150 miles of boundary drift and exclosure fences as shown in this plan.	No; the existing goats within the fenced areas would still remain without actual goat reduction efforts.	Yes, this is a key to any plan to reduce goat populations; without fencing, goats constantly move into the park from adjacent ranch lands.	Fences on the landscape are inconspicuous--but they are present (a detracting aspect). Natural forests will become re-established--more than offsetting the presence of fences.	Fences proposed in this plan are technically compatible to "wilderness" in that they are the minimum necessary measure to protect the wilderness.	---
3. Control goats by a citizen deputy ranger program.	No; experience shows clearly that year-round hunting with no bag limits does not hold goat populations low enough for endemic plant survival.	Yes, but must be used with other reduction efforts and fencing.	There is some minor vandalism on the part of a very few citizen deputies.	None	Public are more inclined to support the goat control efforts when the goats killed are put to beneficial use. This does.

Table 8. Alternative techniques in controlling goat populations at a low enough level to protect the park's remnant Hawaiian ecosystems from further depredation and competition by goats. (Continued)

Alternative technique	Can this technique alone effectively reduce and maintain a low enough goat population that endemic plants are not affected by goats	If used with other techniques--can this help to effectively reduce and maintain a low enough goat population that endemic plants are unaffected	Effect upon scenic environment	Effect upon park wilderness designation	Social or other consideration
4. Control goats with park personnel conducting goat drives (sell live goats).	No; experience shows clearly that drives alone are inadequate to reduce and hold goat populations low enough for endemic plant survival.	Yes, but must be used with other reduction efforts and fencing.	Drift fences on the landscape are inconspicuous--but they are present.	None	Public are more inclined to support the goat control efforts if goats are live trapped, or are put to beneficial use. This does.
5. Control goats by private operators conducting goat drives and catching live goats for sale.	No; experience shows clearly that drives alone are inadequate to reduce and hold goat populations low enough for endemic plant survival.	It helps at very initial stages of reduction, but fails to cope with remote and difficult areas.	Drift fences on the landscape are inconspicuous--but they are present.	Commercial goat operations (that to some may border on goat ranching) are probably illegal.	Private operators, to remain in business, must operate on a sustained yield basis. Hence, this technique results in a continuously high goat population.
6. Control goats by rangers hunting goats with dogs and rifles.	Not alone; but this technique is effective in areas too remote or difficult to interest citizen deputies or to be susceptible to goat drives.	Yes, but must be used with other reduction efforts and fencing.	None	None	Public may be more agreeable to this technique than other killing techniques done by park rangers.

Table 8. Alternative techniques in controlling goat populations at a low enough level to protect the park's remnant Hawaiian ecosystems from further depredation and competition by goats. (Continued)

Alternative technique	Can this technique alone effectively reduce and maintain a low enough goat population that endemic plants are not affected by goats	If used with other techniques--can this help to effectively reduce and maintain a low enough goat population that endemic plants are unaffected	Effect upon scenic environment	Effect upon park wilderness designation	Social or other consideration
7. Control goats by poisons.	No; not without fencing to prevent constant infiltration of goats from outside the park.	Yes, but must be used with other reduction efforts and fencing.	Probably none	None	Poisoning as a technique may be repugnant to a large segment of the public. Too, would poison cause secondary poisoning of the Hawaiian hawk?
8. Control goats by birth control chemicals.	No; no known technology is available that is effective with a widespread, high populated area.	No; no known technology is presently available that is effective with a widespread, high populated area.	Probably none	None	---
9. Control goats by shooting from helicopters.	Not alone; it would have to be used with the fencing efforts to hold populations to low levels.	Yes, but must be used with other reduction efforts and fencing.	None	Probably none	Probably the general public is more agreeable to goat reductions by drives, citizen deputy ranger, and park ranger hunts than by mass shooting from helicopter.

CONSULTATION AND COORDINATION

CONSULTATION AND COORDINATION IN THE DEVELOPMENT OF THE PROPOSAL AND IN THE PREPARATION OF THE DRAFT ENVIRONMENTAL STATEMENT

During the preparation of the natural history resources management plan, many sources outside the Park Service were consulted for their knowledge, suggestions, and recommendations. The following list is indicative of the types of sources contacted:

Rare endemic plants:	Mr. L. W. Bryan, Kailua, Hawaii Drs. Otto and Isa Degener, Volcano, Hawaii Dr. F. R. Fosberg, Smithsonian Institution International Biological Project scientists Dr. Charles H. Lamoureux, University of Hawaii Mr. Libert Landgraf, Hawaii Division of Forestry Mr. Russel K. LeBarron, Hawaii Division of Forestry Dr. Howard A. Powers, retired U. S. Geological Survey Mr. Ernest Pung, Hawaii Department of Natural Resources Dr. Harold St. John, Bernice P. Bishop Museum Mr. Tom K. Tagawa, Hawaii Department of Natural Resources
Rare endemic birds:	Mr. Winston E. Banko, U. S. Bureau of Sport Fisheries and Wildlife
Nene propagation:	Mr. Ernest Kosaka, Hawaii Division of Fish and Game Mr. Clinton H. Lostetter, U. S. Bureau of Sport Fisheries and Wildlife
Goat and pig control; fencing proposals; deputy ranger program:	Hawaii Audubon Society Hawaii Conservation Council Hawaii Island Fish and Game Association Hawaii State Division of Fish and Game

COORDINATION IN THE REVIEW OF THE DRAFT ENVIRONMENTAL STATEMENT

Advisory Council on Historic Preservation

Department of Agriculture
Soil Conservation Service

Department of Defense
U. S. Army

Department of the Interior
- Bureau of Indian Affairs
- Bureau of Mines
- Bureau of Land Management
- Bureau of Outdoor Recreation
- Bureau of Reclamation
- Bureau of Sport Fisheries and Wildlife
- Geological Survey

Department of Transportation

Environmental Protection Agency

State of Hawaii Clearinghouse

State Liaison Officer

County of Hawaii

Wilderness Society

Sierra Club

The Nature Conservancy

University of Hawaii

Bishop Museum

Society of American Foresters

Congress of the Hawaiian People

The Hawaiians

Audubon Society

Life of the Land

APPENDIXES

Appendix 1

Plants considered for planting program but not included.

1. Not included because of inadequate knowledge regarding taxonomy, former distributions, or culturing techniques.

   Clermontia hawaiiensis

   Clermontia peleana

   Cyanea carlsonii

   Cyanea bryanii

   Embelia pacifica

   Eurya sandwicensis

   Kokia rockii, kokio

   Labordia sp.

   Pelea clusiaefolia cuneata, alani

   Pelea oblanceolata

   Pelea radiata

   Portulaca hawaiiensis

   Portulaca sclerocarpa

   Pseudomorus sandwicensis, aiai

   Urera sandwicensis

2. Not included because we believe they were never native to Hawaii Volcanoes National Park.

   Argyroxiphium kauensis, Kau silversword

   Acadia koaia, koaia

   Claoxylon sandwicensis, poola

   Gardenia brighami, nau

   Gardenia remyi, nahu

   Platydesma remyi, pilo kea

   Pterotropia dipyrema, ohe ohe

IN REPLY REFER TO:

United States Department of the Interior

NATIONAL PARK SERVICE
HAWAII VOLCANOES NATIONAL PARK
HAWAII 96718

September 25, 1972

Memorandum

To: Superintendent, Hawaii Volcanoes

From: Pacific Archeologist

Subject: Archeological Reconnaissance Survey--Hawaii Volcanoes

On September 25, 1972, at the request of the Superintendent of Hawaii Volcanoes National Park, I made a preliminary archeological reconnaissance survey of the proposed fence lines at Hawaii Volcanoes National Park.

All the proposed fences are in either recent lava fields or parallel to or adjacent to older fence lines. Except for some features near Kuee Ruins, which will not be affected by this action, there are no archeological features anywhere within several miles of any of the proposed fence lines. Therefore, I respectfully submit this memorandum for your transmittal to the Regional Archeologist for an archeological clearance for your fencing project.

Edmund J. Ladd

cc:
Mr. Douglas H. Scovill, Western Region Archeologist
State Director, Hawaii

United States Department of the Interior

NATIONAL PARK SERVICE
Arizona Archeological Center
P. O. Box 49008
Tucson, Arizona 85717

Tel. No. (602) 792-6501

IN REPLY REFER TO:
H22
X-H2215 HAVO

October 12, 1972

004 - HAVO
Clearance No.

Memorandum

To: Superintendent, Hawaii Volcanoes

From: Acting Chief, Arizona Archeological Center

Subject: Archeological Clearance

The effects of the following project on archeological resources have been assessed:

Proposed fence lines, Hawaii Volcanoes National Park.

The basis for this assessment is:

Archeological survey by Pacific Archeologist reported in memorandum to Superintendent, HAVO, September 25, 1972.

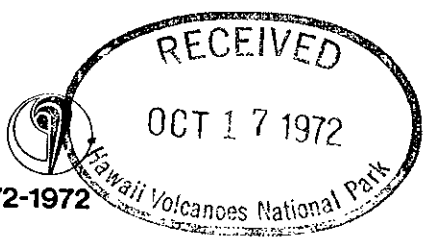
__X__ Since there is no substantial evidence that significant archeological resources will be affected adversely, clearance to proceed is hereby provided.

_____ Since the identified adverse effects of the project on archeological resources have been mitigated by the completion of appropriate investigations clearance to proceed is hereby provided.

If concealed archeological resources are encountered during construction, please take all necessary steps to protect them and immediately notify this office so that appropriate action may be taken.

Douglas H. Scovill

cc:



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